Ask A Biologist Vol 075 (Guest Barbara Thorn)

Tales of Termites

Termites are one of the planet's best recyclers. Yes, we usually think of these insects as something that destroy homes and need to be exterminated. It turns out that these critters are tiny 'green machines' that are critical to the planet. Dr. Biology learns about the history, social nature, and the important role termites have from entomologist, **Barbara Thorn**.

Transcript

[beeps – electronic lock and vault door opening]

Dr. Biology: This episode of Ask a Biologist is being pulled from our special collections that have been stored in our secret vault. This is Ask a Biologist, a program about the living world, and I'm Dr. Biology.

Today we have a tale of the living dinosaurs, but not the type of dinosaurs that you might be thinking of. Instead, these are the dinosaurs of the termite world. A story of war, and change, colonies battling colonies, and workers changing into kings, sometimes queens and other times even a soldier.

Our guest today is Barbara Thorn, Professor and the Director of Biological Sciences graduate program at the University of Maryland. She's been studying termites and the really interesting world that they live in. Some of these colonies, when they meet each other, the battles begin. Barbara, I want to thank you for joining us on Ask A Biologist. It's wonderful having you here.

Barbara Thorn: Thank you.

Dr. Biology: For some of the regular listeners of Ask A Biologist, I know they're wondering, "Why is it they're always talking about insects? Why are they often social insects?" They just don't realize that we actually have one of the best social-insect groups at Arizona State University.

The other reason is, well, there are a lot of insects out there. If you're going to study something in the living world, especially in the animal kingdom, this can be really cool stuff, right? That's one of the reasons why we have a lot of people that do this. You study termites. Now my question is, why termites?

Barbara: Dr. Biology, I think you set that up really well. Why do people study insects and why do so many people study social insects? When you actually look at all the different

insects in the world, it turns out that the social insects are a huge group of them. They dominate all the other types of insects.

Right there, social insects, there's something about that very interesting organization that has made them very, very successful and very diverse. They're in many different types of habitats and they're very important in those habitats. Termites, for example, are ultra-cool because they are responsible for, say, tropical rain forests. You wouldn't think that, right?

Dr. Biology: Tropical rain forests, termites. They wouldn't go side by side.

Barbara: They don't go side by side. And yet, when you think about it...You think about a tropical rain forest, "Oh, how cool. There's monkeys in the trees, and there's great, big, tall trees. There's vines all around, and monkeys using those vines to swoop like Tarzan," and whatever.

All this just incredible diversity, and huge flowers. But all of that vegetation, all of that green stuff, the trees and the plants are sucking up nutrients from the soil. Even though you see a tropical rainforest looks really lush, in fact, it's hurting and the soil, the nutrients are gone.

They rely on the termites to recycle. The termites are the ace recyclers in the whole planet when it comes to plants.

Dr. Biology: They're like the green machines out there.

Barbara: They are. That's a great term. When a storm comes through and knocks down a big tree, poles vines, and all these drama from the plants and they die, but on the termites margin. The termites are able to digest dead wood or dead plants, of any type. That's rare. There aren't too many animals that can do that. Termites do it quickly, then all those nutrients from the plant are put back into the soil and new plants can grow.

Termites are really, really important for that. They're important where we live up her in the United States for aerating the soil that hang around in the soil there, digging around, and moving things around. That helps the roots of plants get oxygen so they grow better.

Anyway, for all sorts of reasons, termites are cool. Why do I study them? For those reasons and because they are important in our houses. We don't want them there. We want them in the tropical rainforest, we don't want them in our houses.

Another aspect of termites and why I got in to study them in the first place, is what you also talked about, that social insects are so common. Lots of people know about a honey bee, the honey bee queen flying off then swarms in the honey, the workers, the drones, and ants, they're all over, and wasps...Let's not talk about wasps too much. They sting but they're really intersecting insects.

Those are all cousins, they're closely related. They all have these amazing social systems with the queen and workers that hep the queen stay in the colony. There's another major group of insects that has that same kind of elaborate social organization, that's the termites.

The termites are a very, very different group of insects. This a is a case where we call it "convergent evolution. " The two very, very separate types of beasts, in this case, the ants, bees, and wasps, on one hand, and termites on the other hand have...For totally separate lineages, they've developed a very similar colony organization and life organization.

You have a queen termite, you have a queen honey bee, and you have lots and lots of workers with the termites and you have lots and lots of workers with the honey bees foraging for new food, and soldiers, and in the case of termites you got the king, really neat stuff.

That is engaging and as Biologists we always like to ask the big questions. Kids are always curious and it's great to ask questions. Don't worry about whether they're good questions or bad questions. If you're curious about it, that's a good thing, and ask the question. How these complex social systems evolve that are social insects, that's a big question.

Dr. Biology: The interesting thing for you is you've been studying, what happens when two separate colonies of termites actually find each other. They bump into each other. They're on a tree, trees are really big. Been a long time not seeing each other but all of a sudden they come in contact and it's an interesting story.

It's that tale of battles and wars and the kings and the queens are ousted. You actually showed a really neat illustration. It was a chess board and I liked that. Can we talk a little bit about that? It illustrates what you were talking about.

Barbara: It does. It's an amazing illustration, very clever. It was done by a National Science Foundation artist named Zina Deretsky. What it depicts is the two teams on a chess board. You've got the different players on the chess board and one of them is the queen.

The queen, she's moved to the other side of the board. When she gets there she is replaced by a pawn and the pawn becomes the new queen. That is what's happening in natural situations with termites. You start out with two teams, just like in chess, and the two colonies, two little termite families, when they meet the queen is assassinated.

Dr. Biology: Whoa.

Barbara: Drama, and then one or more of the workers in the termite colony, like the pawns in the chess game, they replace the queen. They become the new egg layers and do the duties that the queen did before she was assassinated. We've been looking at that as a model for what might have happened when termites first evolved, which was a long time ago, 130 or 140 million years ago.

Dr. Biology: That's a million, with a big "M."

Barbara: It is. If I had a time machine, that's where I'd be. Going back and seeing what was actually happening. I wish I could do that. Maybe in the future we'll be able to do that, but right now the best we can do is to look at the termites that are alive now, that have retained some of the characteristics of their ancient ancestors. That's what has sparked this study, is looking at the modern termites.

Dr. Biology: I think you even called them "modern dinosaurs?"

Barbara: Yeah, they're sort of the dinosaurs of living termites. That's how I think about them, but actually termites evolved a long time ago, the late Jurassic early Cretaceous. There were lots of dinosaurs around and probably ate termites.

Dr. Biology: We know why you might be studying them, so we can answer some questions about evolution. In fact, this was something that Darwin was having a little bit of a problem with.

Barbara: Absolutely. Darwin wrote his manuscript for his key book, "On the Origin of Species," including a section on social insects but it troubled him, because the kicker for Darwin was his whole theory was based on the theory of evolution by natural selection.

The winners in the evolutionary game are those who actually produce offspring for the next generation. He knew that honey bees were out there who didn't reproduce, that the worker honey bees were sterile. That was kind of a show stopper for him.

Instead of sweeping it under the rug he parked his whole big book manuscript in a drawer for close to 20 years. That was one of the reasons, he couldn't figure out the social insects. He wondered if they were an exception to his whole theory.

Dr. Biology: Because there was a long delay between his travels on The Beagle, and actually publishing this manuscript.

Barbara: That's right. One of the reasons that he delayed was the social insects, which we come back to asking big questions. This is something that still interests evolutionary biologists, is the evolution of sterile members of social-insect colonies, which turns out to be most of the colony.

How did sterility evolve? It's still a very contentious subject. We'd love to hear Darwin's current opinion about it. I think he'd be very excited by all the work that's been done.

Dr. Biology: It's the thing about science, it's always changing. We're learning more things. We re-evaluate what we've learnt before. That's why we need more scientists.

Barbara: Absolutely. A lot of people get intimidated by, "Oh, there's so much to learn," and "What if I make a mistake." Those fears are natural, but the cool thing about science is that, if you get interested in whatever, be it termites or outer space or microbes, and you really start learning about it, you become an expert pretty quickly.

You just pick one topic, of snakes or something, and you could learn a lot about them that the kid next door doesn't know. Already, you're an expert. That's really how, when you get serious about science, you dive into something and you don't worry about the mistakes, because we all make mistakes and we continue to make mistakes.

That's actually how you learn, by making a mistake and then you realize, "Oh, that's for this reason," and you get it. It does seem intimidating, there is a lot to learn, but it's also logical and it's fun. The super-fun part is that you're making new discoveries.

Dr. Biology: It's not unlike some of the very complex computer games today. If you start out at level 10, you'll never get anywhere, so you usually start out maybe a level before level one, that teaches you how the game works. Then you go one, two, three, and it gets more and more complex, not unlike science.

Barbara: Yeah, that's a great analogy.

Dr. Biology: Again, with games and science, if you like what you're doing, time goes by. It's amazing how fast you learn things and you learn techniques. How did you get started with termites?

Barbara: I got excited about termites for the same reason that Darwin was interested in social insects. This whole idea of, "How did they evolve? What was the driving force that led to these complex societies?" There were lots and lots of people studying ants, bees, and wasps.

I thought, "Well, there's a lot of people on that level [laughs] and playing the game, and I'll just go back to the first level, but do termites, where there's fewer people, and yet it's a very exciting system."

Dr. Biology: When you got started, did you figure that you're going to be doing research for this long on termites?

Barbara: Honestly, I had a feeling I would. It was the kind of thing that felt like a good fit for me. But I have had the privilege of doing a wide variety of studies with termites. It hasn't just been one thing, which is another way to have a wonderful career in science.

What I've been able to do is to travel many different places in the world and work on a whole different variety of termite species, asking different questions about them, sometimes about their genetics, their evolution or their behavior. To me, that's been a great fit with interests and opportunities. I've loved it.

Dr. Biology: All those things, when it fits in that realm, it's not uncommon for people to look at basic research, and if you're not in that game, if you're not playing that game, you don't always see why you'd want to play that game. Why are they doing that, what's the benefit? Many times, humans, we have a tendency to think everything has got to be all about us.

In this case, not only do you do the basic research but that basic research has actually turned into some very important things for us. This comes back to...You were talking earlier about why we like these termites, we need the termites. As a matter of fact, without termites we'd be in deep trouble, even if we'd be here. We don't necessarily want them in our house.

Barbara: Absolutely.

Dr. Biology: In this realm, you actually hold some patents, I've heard. With patents people think business. Have you seen your science and business crossing paths?

Barbara: Yeah, and I think that's another avenue that science can take people, when they don't even expect it. In my case for example, it used to be that the way that people controlled termites around houses was to spray all sorts of nasty pesticide on them. That put pesticide around homes, and that was a very persistent pesticide, and so dangerous. That was taken off the market.

All of a sudden, there weren't the tools to protect homes from termites. We as humans, we build our houses out of termite food...wood. Of course, we want to keep the termites happy in the forest, in the desert or whatever their normal habitat, but not in our homes. That was at a point that I had begun my termite studies so that I really was learning about the biology of the insect.

When we now needed to create new ways to detect them, to manage them, to prevent them getting into houses, to control them...I won't say I could think like a termite, but I could psych out how they would behave in a certain situation, or foods they would like to eat, or types of homes they were more likely to infest.

Working with a colleague of mine, James Traniello at Boston University, our goal was to develop an approach for managing termites that would be less reliant on widely broadcast pesticide and specifically target the termites. We developed what is called a "termite bait," that is like a cookie that termites can't resist. If they bump into it they want to eat it.

We laced that cookie with a pesticide that really only the termites would eat because they're the ones that would encounter the cookie. There aren't too many things that eat the kind of cookies termites like, that are made out of dead wood.

The principle was that some of the termites in the colony would come and feed at the cookie, then pass along the pesticide to their friends in the colony. At least for once they were eating a house, they would then go away.

Dr. Biology: How many patents do you have?

Barbara: I have three termite ones, and one other one. It is a way that if you're developing new ideas as a scientist and potentially new technologies and there may be ways to apply it in ways you didn't even think of when you first started the study.

I think it's a good thing for all of scientists to do to, one, communicate their work, and learn how to tell people what they're doing that doesn't sound like just some narrow, narrow study of scales of snakes or whatever, and why is it important or what can you learn from that system that then you could apply to a different system.

Communicating is very, very important, explaining what you're doing. Also thinking about applications that might help people.

Dr. Biology: When you were talking today, there was a word that you used. It was actually in your title. Although we don't use...This isn't a big word, it's not very long, but it's a word that a lot of people don't hear..."eusocial." Can you talk just a little bit about eusocial?

Barbara: Eusocial, it basically means highly social. If you're just social, like humans, we're social, right? We do Facebook, we do...

Dr. Biology: There's Twitter out there...

Barbara: Love, being with each other, parties. You want to be alone at some points, but you like company. Monkeys, wolves, lions and many things are social in that the live in groups or families. Eusocial is amping it up one more notch, and a higher level of sociality.

It's a term that is restricted for extreme cases like the social insects, which any of them are not only social but eusocial. A honey bee for example, with the queen and the workers, there are three characteristics that if a group of animals has all three of them, they have to have all three of them, they are considered eusocial.

One of them is overlapping generations. The moms and the offspring have to be alive at the same time, or the grandmother and the mom and the offspring. The queen honey bee and her offspring are alive at the same time. That's overlapping generations. And then, something called "cooperative brood care" which means, they all help. They pitch in to help with the nursery to raise the offspring.

The final one is the big tough angle that not too many animals have. Again, it's this one coming back to Darwin, that was the tough spot for him, and that is what's called

"reproductive division of labor", meaning that everybody in the colony does not reproduce, and then there can be a spectrum.

There are certain ones like the queen honey bee, she does the production. She produces all the eggs, for most of them. All the workers in the colony are for the most part sterile. That extreme difference called reproductive division of labor.

Dr. Biology: Humans, we could say, we could do two out of the three, maybe?

Barbara: Yeah. We might do two out of three. A lot of animals are in that boat, they did the two easy ones, well, easier. The really restrictive one, it limits it to a very few animals. Quite diverse animals, so in addition to the social insects that we always think of, there's a mammal called the naked mole rat that lives in Africa.

There are some really cool shrimp, snapping shrimp that live in the coast of Central America. Those are pretty diverse. Insects, mammals, shrimp, all of which have this organization of a queen and many workers that help out, but don't reproduce.

If Darwin had known about the shrimp and the naked mole rat, not much was known at that time, very exciting.

Dr. Biology: When you were talking about the termites, you actually mention how long they live. 18 to 20 years is one of the links of time that was in my notes right now. When most insects, or a lot of insects are measured their lifespan in days, that seems like a really, really long time. Is that really long even for eusocial types of insects or eusocial types of animals?

Barbara: That's a very good question. One feature of these highly social or eusocial insects, is that the reproductive, the queens for example, do tend to live a long time compared to most other insects. When you think of a butterfly for example, they hatch out of the egg, do their little caterpillar for a couple of weeks, they go into their pupa and they emerge from the chrysalis as a beautiful butterfly, they fly around, and mate, and eat, and then they die.

They're relatively short lived. Some social insect, workers maybe as well, we don't really know because it's hard to age them in the field. We do know that the reproductives, the queens and in the case of the termites, the kings too, lives for many years.

The example that you just mention, 18 to 20 years, those are known measurements that we did in our lab of termite royal pairs, the king and the queen that we put together. We find them again alive, healthy, thriving with their colony two decades later and potentially they could live even longer. Not all social insects and not all termites, even the queens live that long but that's on the extreme side.

Dr. Biology: Still impressive to me.

Barbara: Very impressive.

Dr. Biology: I have a new respect for the termite.

Barbara: Termites do get a bad rap, has a nasty reputation for eating houses. Remember, tropical rain forests would not exist without termites and they're interesting with their kings, and queens, and colony organizations.

Dr. Biology: I would say for those who say, "What if we don't have tropical rain forests, we don't need those, no big deal," I want you to go out there and do some homework. Find out what would happen hypothetically, if we have no tropical rain forest.

You are going to find a very interesting story and one that maybe will get you thinking about, "These green machines, these termites, we really owe our lives to them." On Ask A Biologist, we always ask our guest three questions. The first question is, when did you first know you wanted to be a scientist or a biologist?

Barbara: That's actually a good story with me. I absolutely did not want to be a scientist. I did not like science in elementary school, junior high, or high school. With the passion that I didn't like it so much, I went to a college that I chose because I wouldn't have to take science.

Got there, they made the very good point that to be an educated person you need to explore lots of different things and be exposed to, and learn how to think, and so forth, all sorts of knowledge. So, I took a couple of science courses just as exploratory and loved it.

The first course I took was called, "The Earth, Moon and Mars". The things that I loved about science were the logic and the precision, and then the excitement of new discovery. Once I was hooked, for various reasons, navigated to biology, and then into genetics, and bugs as systems to look at and then I read a book on insect societies and that got me hooked on social insects and termites.

Dr. Biology: Was this the book by Ed Wilson?

Barbara: It was. I say, I'm a case where I didn't know from early on that I wanted to be a scientist, but I hadn't really given it up a fair shot. Sometimes, all of us have had teachers that haven't very inspiring, and they were boring.

If you're out there and you're dealing with that kind of a situation where it hasn't got hooked on science, go read something you're interested in. Forget what the teacher is talking about, or your class is covering, volcanoes or something that does or doesn't interest you, just go and read about something that really is of interest to you. See if that makes it a little more exciting. Go in that direction.

Dr. Biology: I know how you got started. I'm going to take it all away. You can't be a scientist of any kind and most of my scientists love teaching too. I want you to stretch. I'm going to take that away from you and I'm going to give you the gift of whatever you want to do, you get to do. It's not as if you think you'd be able to do it. What would you be or what would you do?

Barbara: That's a very difficult question. If you asked me that about what other direction in science I'd want to go I could tell you, but for a field? I do like writing. Maybe I would have done that. To be fair, perhaps I didn't know about enough. I didn't give other fields a chance either, there are many directions to go. For me personally, the way I think, the way I like to discover new things, science is a very good fit for me.

Dr. Biology: If you went into another field of science, I'll let you answer that one?

Barbara: I think that what changes there is that there are new developments all the time, and new technologies. You can ask questions that you couldn't have asked years ago.

To me now, the field of genomics, looking at genes, really getting down in the dirt and actually seeing what we're all made of, and the variation there, how it's controlled, that's very exciting. I think many dimensions of neurobiology and all the connections now that are possible by merging different fields of science, biomechanics and computational biology.

Dr. Biology: Bioformatics, large numbers. We have a whole new world that is just opening up to us.

Barbara: There are no barriers any more, that's a good thing.

Dr. Biology: My last question, what advice would you have for an up and coming scientist to be?

Barbara: The big thing is, keep asking questions. Just ask question and don't think that's a stupid question or a dumb question, or it's obvious. Just keep thinking of new questions and follow things that are exciting to you, follow your passion.

The other advice I'd have is, be nice to people. Treat people well because your opportunities, to a large degree, are going to depend on people wanting to mentor you. If you're a classy, solid, honest, hardworking person, you're going to be getting lots of opportunities and people are going to want to invest in you.

Dr. Biology: Barbara Thorn thanks again, I really appreciate you being on Ask A Biologist

Barbara: Thanks, Dr. Biology.

Dr. Biology: You've been listening to Ask A Biologist, and my guest has been Barbara Thorn, professor and director of The Biological Sciences graduate program at the University of Maryland.

The Ask A Biologist is a 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 askabiolologist.asu.edu or you can just Google the words, ask a biologist. I'm Dr. Biology.

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