

## **Ask A Biologist Vol 078 (Guest Raghavendra Gadagkar)**

### **Queen Switcharoo**

According to an old German proverb the animal that is the subject of this show was made by the devil. Dr. Biology gets a lesson about this devilish study subject from biologist **Raghavendra Gadagkar**. They talk about what he has learned from years of observing these misunderstood animals. There is even a surprise ending that we call the 'Queen Switcharoo'.

### **Transcript**

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[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.

**Dr. Biology:** This is "Ask a Biologist," a program about the living world, and I'm Dr. Biology. For today's show let's start off with a quiz to see if you can figure out what animal our guest has spent their career studying.

The first clue, they've been around since the time the dinosaurs were walking on this Earth. Of course there are no dinosaurs today, but they're still around.

This animal is also highly social, which means, among other things, they live in groups and they communicate with each other. The groups they live in are called colonies.

All right. You're beginning to get the idea about what it could be? OK. I'll give you another clue. They also pack a pretty wicked stink. Now before you draw any conclusions, I want you to wait for it, the last clue.

This animal lives in nests made of paper. That last tidbit might have tripped you up. I bet some of you were thinking of bee colonies right up to that point.

The animal is an insect, but it's not a bee. It's a paper wasp. Not sure what a paper wasp is? No problem we'll learn about them today.

My guest is Raghavendra Gadagkar, Professor at the Center for Ecological Sciences and Center for Contemporary Studies at the Indian Institute of Science in Bangalore, India. His work has been focused on the social evolution of wasps. This has led to the publication of several hundred papers, yes that's hundreds, on these fascinating insects that make their homes out of paper. It's not just any paper, it's paper made by wasps themselves.

Raghavendra Gadagkar thank you for joining me on 'Ask a Biologist.'

**Raghavendra Gadagkar:** You're welcome.

**Dr. Biology:** Let's start things off with a little bit about our wasps and how they're different and how they're the same as a typical honey bee colony.

**Raghavendra:** The wasps unfortunately, have gotten a bad name, and I think that's very undeserved bad name. In fact, there's a German proverb which translates as follows, "God made the bees and the devil made the wasps."

[laughing]

**Raghavendra:** But the wasp is a wonderful creature. It stings if you disturb it, it doesn't sting if you don't. We've been studying wasps for over 30 years. We have seldom got stung when we were aware that we're dealing with a wasp. It is when you accidentally bump into a wasp that's when you get stung.

**Dr. Biology:** What about the social wasp and the social bees?

**Raghavendra:** The most famous social bee, of course, is the honey bee. The honey bee builds its nest from wax. Honey bees have a single, large, fertile queen, a small number of lazy drones, and a large number of small, sterile, female workers. In the wasps, you have some wasp species which are almost as sophisticated as the honey bee, with a large queen.

The wasps I study are considered primitive in their social organization, in the achievements of their societies. The interesting thing about these primitively social wasps is that there is no queen who looks different from the workers. It's a bunch of female wasps, they all look alike, they're all very similar, one of them becomes the queen.

**Dr. Biology:** In the earlier show, we talked also about the honey bee nest, and it was with Brian Smith.

He was talking about if you could take all the neurons that all the bees have in a colony, that all that processing power would be about the equivalent of a human brain.

**Raghavendra:** Of a human brain.

**Dr. Biology:** What about a wasp colony?

**Raghavendra:** About the same. I don't think there's that much difference, but usually, the number of individuals per colony is small in the primitive social wasps, but in the advanced social wasp, they can be much larger than in a honey bee colony.

This is a very interesting comparison to what an advanced wasp society, or a honey bee society, is it has 50,000 little brains running around. We have one single brain, but there is an interesting trade-off. Because we have one brain, we have great power of integration, but our power of collection of information is very limited because it's one piece.

**Dr. Biology:** Right. We can only go in one place.

**Raghavendra:** That's right. The honey bees can go into hundreds of different places, gather information, but their powers of integration are limited compared to ours because then these worker bees have to talk to each other.

They do talk to each other, but perhaps not as efficiently as one neuron in my brain talks to another neuron in my brain.

**Dr. Biology:** You have these primitive wasps and the more advanced wasps, what is the difference? Now, I noticed you mentioned that, it seemed the first thing was, on the primitive, all of the females look the same, but one of them is the queen.

**Raghavendra:** Yes.

**Dr. Biology:** I have a feeling that looks are deceptive. That even though they all look the same the queen is really a little bit different, either behaving different and probably even their physiologies are different.

**Raghavendra:** The queen definitely becomes different after she becomes the queen. She is rather like any other worker before she becomes the queen. In fact in the species that I study in South India I can take a colony, identify the queen and experimentally remove the queen. Within minutes, I have one of the workers taking over.

**Dr. Biology:** Within minutes?

**Raghavendra:** Within minutes.

**Dr. Biology:** Wow. So there's no battle, there's no big vote going on that we can think of?

**Raghavendra:** All the processes that are required to elect a successor appear to take place before the queen dies.

**Dr. Biology:** I have a queen, you remove the queen, within minutes we get a new queen. What if you take that queen out? Do we have a new queen within minutes after that?

**Raghavendra:** Absolutely. If we remove the first queen, we have a second. If we remove the second, we have a third. We remove the third, we have a fourth. We remove the fourth, we have a fifth. We remove the fifth, we have a sixth. And then my students said, there's no need to continue anymore.

**Dr. Biology:** That's amazing, they've actually set up a tiered system where they've decided who's first, second, third, fourth and fifth. Wow, and all the way down.

**Raghavendra:** All the way down. You could imagine that this is a pretty good strategy because you don't want to have an internal conflict when you have lost the head of your organization. When someone from the outside is trying to take over. So you want to have an extremely peaceful transition. The wasps are always subject to threats from outside. In fact other wasps, of their own kind, are often waiting to take them over.

**Dr. Biology:** Oh really?

**Raghavendra:** Yes, and they can take over. So if you're offering, so to speak and then you have a conflict, then you're very vulnerable. In the tropical environment which these wasps live in, where I live, the threats are much greater and I think this settling of the identity of several successive successors in peace time, if you like, is an adaptation of this very nasty tropical environment.

**Dr. Biology:** Right. So they're prepared. What if I'm the second in line, I'm the next one to be the queen, and I don't want to wait? How am I kept from becoming the queen? How do I not take over when there's a queen there or why don't I take over?

**Raghavendra:** Most of the time the queen is generally superior to the next one. But this will not go on forever, the queen will grow older. When she becomes older then of course she becomes inferior to the next one and there is then a transition from the old queen to the new queen.

But sometimes it happens that the old queen is still young and has a long time to go but by chance the second one is actually ready too early. Then we have found to our great surprise that she can actually bring about a split in the colony and take a fraction of loyal worker with her, leave and start a new colony by herself.

**Dr. Biology:** The other thing that was kind of curious to me was when we talk about social insects, we have a tendency to think, especially with bees, that the queen is in control of everything. That they coordinate everything and they're the whatever, the president, the queen, the king, the everything. Everything is going to run through them. that's not really true with the bee colonies.

**Raghavendra:** In fact we know that worker bees organize themselves and we call this self-organization. We call it decentralized rather than centralized. We call it bottom-up rather than top down. [laughs]

**Raghavendra:** This we have now known for some time but until recently we believed that at least in the wasps, the queen is under control and it's top down. We have found to our surprise that's not true. Even in these little wasps with a colony consisting only of 20 individuals there is a self-organization amongst the workers, it is a decentralized control, and the queen is not the wasp, telling the workers what to do.

**Dr. Biology:** They are very similar to the honey bees?

**Raghavendra:** Yes.

**Dr. Biology:** How did you figure that out?

**Raghavendra:** In such species, it was believed that the queen uses physical aggression. By biting, chasing and bullying workers, she prevents them from becoming queens too early, and she's still healthy, and she also makes sure they work. This was the wisdom at that time, and we wanted to test this wisdom in our species of wasps in South India.

We found to our surprise that the queen in our species is a particularly relaxed individual. Shows no aggression. Doesn't run around interacting with the workers. She's in complete control as far as reproduction is concerned. Nobody lays eggs as long as she is alive.

We wondered how she manages to maintain this monopoly on reproduction, and we discovered that she actually has a chemical weapon, through which she maintains this monopoly and prevents. Basically, she can sterilize the workers with the chemical weapon.

**Dr. Biology:** I see.

**Raghavendra:** But then we said, OK, that's fine, but how can she get them to work with the chemical weapon? Sounds likely that I send the chemical thing then I say go and work. Why should the workers obey? We started understanding how the workers work, and we found that even if we remove the queen, the workers continue to work.

They bring food, they feed the larvae, and we have also now understood how those workers whose job it is to feed the larvae, and who, therefore, have information about who is hungry. Whether the colony is hungry. They then convey this information to the wasps working outside the colony and bringing food. That's how they regulate each others behavior.

The colony, they bring food when they need it, and stops bringing food when they don't need it. The queen had no role in this.

**Dr. Biology:** You actually brought up an important thing that we haven't talked about, the same thing in a bee colony. There are different roles for the different bees, and partially it's due to age, do wasps have similar roles or do they have a whole different series of roles?

**Raghavendra:** Very similar roles. Young wasps work indoors as young bees do, and older wasps work outdoors as older bees do. We have been able to show that this is not absolute age. The bees don't say "oh, I'm now three weeks old, I should go out".

The wasps and the bees seem to have a way of finding out, by the relative to everybody else. or " I am one of the oldest in individuals, I should go out and work." Don't matter what my actual age is. I am the youngest in New York I better stay back and work at home.

You can actually manipulate this. You can remove all the older bees. Then younger bees, when army don't go out, started going out. You remove the young bees, the older bees when army don't work at home, they start staying home and working.

**Dr. Biology:** The wasps the same thing?

**Raghavendra:** Yes, this is what we have shown with the wasps. But similar things happen with the bees.

**Dr. Biology:** OK. So there are no real battles between the females as far as becoming a queen. It's just a matter of, if one gets to be superior of the existing queen, she might take a group of other wasps and go create her own colony.

**Raghavendra:** Yes.

**Dr. Biology:** OK. Do you think that they avoid that because if they actually were aggressive with each other, it would be a problem for the colony itself? If they had all out war amongst themselves, is this a bad thing and they just figured this is the better way?

**Raghavendra:** This may be the reason why they have evolved. To do what they do, but simply from the perspective of wasps, what we find from our observation is that a worker does not challenge the queen, unless there's a very good chance that she will win. Otherwise, she would just get killed. But when she is very strong, but the queen is super strong, that's when the best way is to leave.

If you watch this, it must be true that she has a complicated and long processes of confidence building in several individuals who were willing to leave with her. It's hard to imagine that they don't have this processes. We don't know how they do it. But clearly they must have a way of building confidence, getting loyalty, and each worker must decide. Will I stay with the old queen, or will I leave with the new queen?

**Dr. Biology:** We don't know that answer yet?

**Raghavendra:** No, but for far too long, people, including biologists have thought of insects as program mechanical robots. Not really thinking. I think that view is unattainable anymore. If you look at the kinds of things they do, it's clear that they must have fairly complicated cognitive processes.

**Dr. Biology:** Well the reason I mentioned that we don't know the answer, and this is an important point because we don't have all the answers, and so young scientists out there that are interested in the world of wasps, there's still more to be learned, a lot more to be learned.

**Raghavendra:** There's a great deal to be learned and it's all waiting there, especially if you simply walk into the woods. There are dozens of species and obvious questions. Biology is one field in modern science, where you could still make fundamental discoveries simply by being an amateur, or being a high school kid. It is still possible to do it.

It's probably much harder to do this in physics. Today, at one time it was, but biology is a completely open field, but it's not happening enough because we teach biology mostly indoors. I think biology classes should be outdoors. The biology teacher must take the kids for a walk in the garden and the woods, anywhere, and teach biology.

I think even high school kids can make new discoveries. Fundamental new discoveries.

**Dr. Biology:** When you were going to school, did you learn your biology indoors, or outdoors?

**Raghavendra:** Well, I skipped many of my classes and stayed outdoors.

[laughter]

**Dr. Biology:** OK. Well, you're not going to be a good role model as far as going to class, but you're an excellent role model obviously as a scientist. OK, we'll let you get away with that.

[laughter]

**Dr. Biology:** You've been working and experimenting with wasps for how long now?

**Raghavendra:** I started as a hobby when I was just in high school. That's when I was like 17 or 18 years old. But it was a long period when it was in a hobby phase. During that hobby phase, I got myself a bachelors Degree in Zoology, a Masters Degree in Zoology, and a PhD in molecular biology.

All the time, continue to watch wasps on the side. The equivalent of not going to the class, but keep doing this. At the end of my PhD I started seriously as a profession. As a professional, I have been doing over 30 years now.

**Dr. Biology:** Well, and I notice you have over 250 papers?

**Raghavendra:** [laughs] yes.

**Dr. Biology:** Wow, you must like writing?

**Raghavendra:** Yes. I have one book, I call it "For anybody on the street." Particularly for young people.

**Dr. Biology:** Which book would that be?

**Raghavendra:** The book is called, "Survival Strategies." It explains my whole feel to the common world, particularly for high school kids and undergraduate students. Then I've written a more advanced book about the life of the wasps themselves.

**Dr. Biology:** What are the interesting things about these wasps? They're called paper wasps, right?

**Raghavendra:** Yes.

**Dr. Biology:** But it turns out, there are a lot of paper wasps, right?

**Raghavendra:** Yes.

**Dr. Biology:** And if that, almost all of them are social?

**Raghavendra:** All the social ones are paper wasps, and again the primitive ones, makes a single open nest with a single comb, which is open and we can watch and we can study it. The advanced ones, makes a very large nest and they have several layers of paper comb, and then they cover it with an envelope of paper. Leaving just a small opening for the wasps to fly in and out.

It can be the size of a football or even bigger. If you open an envelope cover, what they always say, what you see inside is a multi-storey apartment complex with several layers, and all of this is actually housing for the young wasps.

Unlike the bees, the wasps do not store food. The wasps are carnivorous. They eat insects, spiders and meat of various kinds. Unfortunately, they have not invented the refrigerator. They cannot store food. The bees eat nectar and pollen which can easily be preserved.

The bees use their nest both to store food and to rear their young ones. The wasps use their nest only to rear their young ones, and they have to find their food every day.

**Dr. Biology:** I have an image of that the primitive wasp nest here, and it really does look, from any basic look, it's a honeycomb, could be a bee, it's a honeycomb in a small shape. I don't know that it's made out of paper, and so that's the primitive one.

Actually in Arizona, we have the more dense wasp nest. They actually look like a giant, almost brown ball. They have this beautiful layers to them. We said that they're made of paper, are they really made out of paper this nests?

**Raghavendra:** Yes, and you can easily watch wasps bringing some of those fibers, bringing water, mixing them together, making the pulp and keep a plug. That's how you see those layers. Because this is work done over many days. Inside that, of course, there are these layers of comb. When the nest has to grow, they actually have to tear down the outside, put one more floor and then again cover up the outside.

Hundreds and thousands of wasps are working several hours a day. Doing that, very easy to watch them, and this is a fascinating thing to watch.

**Dr. Biology:** When you've been observing an animal for this long, and spend so much time doing experiments, What's the most amazing thing that you've ever seen a wasp do?

**Raghavendra:** The most amazing thing that a wasp does is the following. I removed the queen, and a worker starts to behave like a queen. As soon as I returned the queen, no questions asked. She just goes back to working as she was before unless the queen takeover. This ability to do that, I find absolutely amazing.

**Dr. Biology:** Really?

**Raghavendra:** Yes.

**Dr. Biology:** OK. The experiments you've been doing, a lot of times people think of science being expensive thing to do, and the question I have is "Do you have to spend a lot of money to do your research with your wasps?"

**Raghavendra:** Almost no money. I take particular pride if I can answer the question to is, one is without money, and one is with money, I will, of course, answering without money. I think if you do science with less money, you are given more credit to do that. In fact, most of my experiments, I need no money. But I need observers.

I need spares of eyes. Therefore, I have a lot number of students.

**Dr. Biology:** They're priceless things, aren't they?

**Raghavendra:** Absolutely. My Students are passionate about this. I think it's difficult not to be passionate if a young person is given the opportunity to watch nature in action, it's very hard for that person not to be compassionate about it. Once you become passionate about it, that's when it becomes a hobby.

**Dr. Biology:** Do you use video now? Are you using video cameras...?



**Raghavendra:** Most of the time I use videos, in order to tell other people who want to come to Arizona and give a talk to the students here, of what wasps do, then of course I need a video. I use video more for documentation, for telling others. The actual data collection I find, is much better than manually, than through with your tape.

My attitude towards technology is that, use it when you need it. Don't let technology decide what you should do. You decide what to do, and if the question I want to answer requires technology, I'll use it. If it doesn't require technology, I will not use it.

**Dr. Biology:** Right. "Ask a biologist," I never let my scientist leave without answering three questions. The first one is, when did you first know that you wanted to be a biologist or a scientist? Now I know when you first got hooked on your wasps, but when did you really know you are going to be a biologist?

**Raghavendra:** Long before that actually. When I was very young, long back as I can remember, I used to collect insects, I used to collect tadpoles, I used to bring frogs and feed them at home. I also had a fair amount of free time at that time. I think it's very important for young people, we need to motivate young people and give them free time.

What we do is we keep them so busy with structured education, that there is no time for innovation. We may need to motivate them and then leave them free for them to innovate. I have a lot of time and I used to collect these things, have my own collection. I have what live animals, dead animals at home. For as long back as I can remember, I've been wanting to be a scientist and particularly a biologist.

**Dr. Biology:** Did you have a particular science teacher, or friend, or family member that helped you along the way?

**Raghavendra:** One teacher and one family member. In India, when the time I had to make this decision, you could only specialize in three subjects and not four as they can do today. So I had to choose between a combination of physics, chemistry and mathematics and no biology, or physics, chemistry and biology and no mathematics.

This was hard for me because I wanted all of them. But I had to make a choice, and I almost made the choice of physics, chemistry, and mathematics. Then there was a biology teacher who was helping organize a student based exhibition. Students in the ninth grade had projects and had to go off to the university and display their projects and compete for a prize.

I was one grade lower than that and was not allowed to do this. It dawned that one of the students was supposed to do this dropout for some reason, and this biology teacher picked me out and said why don't you participate in this? and that was the turning point. I participated in this and I got a prize and then there was no looking back.

**Dr. Biology:** All because one student dropped out?

**Raghavendra:** One student dropped out, so I had to hold that chance. Then I have an uncle who was a veterinary doctor. I was so impressed that right at his office, he had a microscope, which I had never had access to at that age. He would let me go and play with the microscope. I pick up

dirty work, or from pond or some various places, and watch it down to the microscope. That made a huge difference.

**Dr. Biology:** It's amazing what's living in that water looks like. We talk about exploring outer space, but inner space, their tiny world, they're some of the most fantastic world that anybody could imagine, and not imagine. Better than any movie.

OK. You're a famous biologist. You're our famous biologist that knows probably more about wasps, certainly these paper wasps, the primitive form, but I'm going to take it all away from you. You can no longer be a biologist, not going to let you teach either because a lot of my biologist want to shift into teaching. What I'm going to let you do is be anything, or do anything you would want if you couldn't be a biologist or a teacher?

**Raghavendra:** I'd either be a writer or an actor.

**Dr. Biology:** Or an actor?

**Raghavendra:** Yes.

**Dr. Biology:** What kind of an actor would you be?

**Raghavendra:** Theater, not film

**Dr. Biology:** Did you ever do any acting when you were a student?

**Raghavendra:** In school yes, I did some acting, and I did some writing, and I would be as passionate about them as I am at being a biologist.

**Dr. Biology:** Did you have a favorite role on your acting, some character that you did that you can remember?

**Raghavendra:** My teacher's wife.

**Dr. Biology:** Your teacher's wife?

**Raghavendra:** Yes. [laughs]

**Dr. Biology:** You play the role of your teacher's wife?

**Raghavendra:** Yes

[laughter]

**Dr. Biology:** Well, that is very challenging. Did you do a good job?

**Raghavendra:** Yes, I did. I got a prize. [laughs]

**Dr. Biology:** You got a prize. Alright. The last question is a little bit easier. We have touched upon this already. What advice could you have for a young scientist, or someone that decide that they

picked the career they thought they would like, but they realized they really are a biologist. What advice would you have for them?

**Raghavendra:** It's never too late to change your career. never. If you are passionate about some subject, then you always have a special advantage or others who have taken it as a part of a structure career. You always look at it differently. It's never too late. If you cannot plunge into a career change, it doesn't matter. I think, 24 hours a day is far more than most of us use effectively.

It's entirely possible for people to have a double career. So to start off in a new career, and let the circumstances make it possible for you to entirely plan the new career. Most of us I think do not use our time effectively. we have enough time for a second career.

**Dr. Biology:** Well I want to thank you for joining me in ask a biologist.

**Raghavendra:** Thank you very much, Dr. Biology.

**Dr. Biology:** You've been listening to "Ask a biologist" and my guest has been Raghavendra Gadagkar. A professor at the Center for Ecological Sciences and the Center for Contemporary studies at the Indian Institute of science in Bangalore India. we've been talking about the study subject, "The amazing paper wasps." Ask about this podcast, it's produced on the campus of Arizona State University, and is recorded in the grass root studio, housed in the school's life sciences, which is an academic unit 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](http://Askabiologist.asu.edu) or you can just Google the word Ask a Biologist. I'm Doctor Biology.

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