TRANSCRIPT

Key Conversations with Phi Beta Kappa

How Nature Communicates Through Eavesdropping with Ximena Bernal

How do frogs communicate in a world full of hungry predators and noisy cities? In this episode, Professor Ximena Bernal joins us to discuss the sensory pollutants of urban life, the impact of the environment on communication among species, and the fascinating phenomenon of inter-species "eavesdropping." From her Colombian childhood guiding her to the research of frogs to groundbreaking research on mosquito hearing, we explore the vibrant, noisy, and often dangerous world of behavioral ecology. We also discuss Bernal's passionate advocacy for Latin American women in the sciences, proving that a career in science is as much about curiosity and patience as it is about data.

Fred Lawrence: This podcast episode was generously funded by two anonymous donors. If you would like to support the podcast in similar ways, please contact Hadley Kelly at hkelly@pbk.org. Thanks for listening.

Hello and welcome to Key Conversations with Phi Beta Kappa. I'm Fred Lawrence, Secretary and CEO of the Phi Beta Kappa Society. Since 2018, we've welcomed leading thinkers, visionaries, and artists to our podcast. These individuals have shaped our collective understanding of some of today's most pressing and consequential matters, in addition to sharing stories with us about their scholarly and personal journeys. Many of our guests are Phi Beta Kappa Visiting Scholars who travel the country to our Phi Beta Kappa chapters, where they spend two days on campus and present free lectures. We invite you to attend. For more information about Visiting Scholars' lectures, please visit pbk.org.

Today, I'm delighted to welcome Professor Ximena Bernal. Professor Bernal is a professor at Purdue University, where she studies animal communication, focusing on how environmental conditions shape signaling, behavior, and survival. Her research examines how predators and parasites exploit communication signals through eavesdropping, as well as how sensory pollutants influence communications networks. She also serves as a research associate at the Smithsonian Tropical Institute. Welcome, Professor.

Ximena Bernal: It's a pleasure to be here.

Fred Lawrence: Frogs. You spend a lot of time with frogs. Frogs have an important role in the cultural imaginary. It's the first of the 10 plagues. Egyptian mythology says many things about frogs. Frogs that turn into princes. So, my first question for you is: how did your interest in frogs come up? And I guess actually, the real question is, did frogs lead you to behavioral ecology, or did behavioral ecology lead you to frogs?

Ximena Bernal: Well, it was the frogs that led me to behavioral ecology. And frogs are really amazing and they're beautiful. But I'm going to be completely honest. When I was a little kid, my first entry into frogs came from them being protectors. I am originally from Colombia, South America, and there were frogs in the... Well, we are one of the countries with the highest diversity of frogs, and they come in different sizes, colors, and are beautiful. But there were some that were, where we live, in little flowers. And I used to have... I had a cousin that was a little bit of a bully. She was my age, but much stronger than me. And her weakness was frogs. She was scared of frogs. So we quickly realized I could have a frog, grab it, and I would have it in my pocket. And if my cousin approached me, I was like, "I have a frog."

And then they were like, "Oh, okay."

Fred Lawrence: So frogs started life as your defense mechanism against a bully of all things. So, were you that kid, the kid who played with animals? I mean, a lot of kids, seriously, a lot of little kids would find frogs scary, like the bully, but obviously, you did not. So was that always true when you think about your girlhood?

Ximena Bernal: Not really. And for a little bit, I felt a little bad as a scientist, because there are many scientists that are like, since I was a little kid, I loved this, and I was passionate. I thought they were really cool, but I was one of those kids that was a little scared of nature at the beginning. But I went to a rural school in which I had that opportunity, and it was introduced to me. And I learned to love it. And apparently, as some of my family members said, they did too much of a good job, because I quickly became so passionate about nature that I wanted to spend a lot of time in nature, and I loved doing field work. But even at that point, I fell in love with frogs. I was curious. I wanted to see what they were doing, and this just looked so unique to me. I never thought I could pursue a science career.

Fred Lawrence: So about that, I mean, do you remember a moment when it occurred to you that not only could this be an area of passionate interest, but that one could actually make a career out of this?

Ximena Bernal: It was many years later. So I got into college, and I was a really good student, and I had broad interest. And for a little bit, I wasn't sure what I wanted to study. And I got into general studies, and I thought I was trying and trying different things. And for a little bit, I even thought, "Well, if I'm good at all these things and I like many things, maybe I should make money." But as I was taking some of these classes on business and all of this, I started thinking about ants instead of people in companies, and I'm like, "Hmm, I kind of like biology." And as I was taking biology, we actually, it was early on, someone came to a class, I was saying that they needed people to go to this field station because it was very remote. It was in the Northern Amazon in a very beautiful area that is a hotspot about diversity, because it's where the Amazon, the Savannah, and the Andes come together and they needed someone to go. And I was like, "Okay, I'll volunteer."

And I went there first to try it as a field course, and then I ended up staying over a semester. I call it kind of a *tranquilo* experience, because I was in the middle of nowhere. And I was with two other people, and we were following these big birds that are called Curassows, and they're like chickens in the forest, to be honest. But we will follow them, and every two, five minutes I was like writing down, okay, what they were doing. So, grooming, walking, I was collecting everything they were doing. And even the first few months were spent trying to get the meals, to see us, and allow them to follow us.

But at that point, I also realized that I love data, because after all this work in the Amazon that was so reassuring and beautiful, I realized I'm curious, I'm patient, I can observe an animal for hours without getting bored. We knew so much about this family, a sample size of one family. And at that point, I started thinking about frogs again, and I'm like, frogs, there are many, and they're great, because you can experiment, you can play them calls, you can record what they're calling. And I was lucky enough to have someone that visited from Spain who was working on frogs, and he was the first person that told me, "I work on frogs. I do research on frogs. That can be something that you do."

And it all started there. And I always liked biology, but I didn't know what the options were. So I thought I had to be a high school teacher, and I do admire high school teachers, but I thought I didn't have the patience to be in that position. Although now I realize I actually love that.

Fred Lawrence: So one of the things you've spent a lot of time studying is the communication between, among animals, particularly with frogs. And of course, I think most of us think of it in terms of frogs communicating with other frogs, but your work has also been that whether they are intending it for that reason or not, there are a lot of other animals that are paying attention to this signaling. So, talk a little bit about this eavesdropping function, as we could call it. That's actually a pretty good description for what's happening here in the frog ecosystem, isn't it?

Ximena Bernal: Exactly. And that's why we use that term, eavesdropping. Although eavesdropping may suggest that it only happens with acoustic signals, and in fact, it's widespread. We know, of course, across all organisms, and it makes sense. It's very convenient to be able to tap into the conversations of other organisms to acquire information that could be used towards your benefit. We do it, they do it. And it happens often within individuals of the same species, like human eavesdropping on humans or even fish eavesdropping on fish. But I'm really interested when in the context in which this is happening across species.

So if you think about the frogs, the frogs are not only super cute, we have to admit that, but they have beautiful voices. And as you said at the beginning, they call, and they call, and when they're calling, the males, they're calling to attract a female.

Females in post-selection prefer calls that are highly ornamented, conspicuous. That's why they're so loud, because females prefer calls that are more ornamented, louder, more attractive, and this has long fascinated and intrigued biologists. Even Darwin was concerned about this. In fact, in one of his books, he says that if you look at the train, basically the tail of a peacock made him feel sick, because he had a hard time explaining why these ornamented and highly elaborated traits will evolve. Because they clearly put the bearer of these traits at risk. And at that point, it was really hard for them to imagine that females will have what they call aesthetic view or will be able to select males based on these traits. But we have come a long way since Darwin, and now it's very clear that females do post-selection on this, and in general, they prefer these kinds of traits that are harder to produce, and there are many hypotheses for that.

But for instance, one of those is that this is a way to select for males that have the ability, so “better” males that can produce these signals. So maybe you have more energy, you're stronger, you can present these signals as honest traits, honest signals, we call them, that they are the best male. In other species, we know that sometimes males are a little sneaky, and males can tap into the sensory system with the female, and use strategies that just excite their sensory system more and make them more attractive.

Fred Lawrence: So far, we've been talking about other non-primate members of the animal kingdom and how they're affecting this, but what about human beings and the impact that we have on their ecosystem as well, in terms of how we affect how they would call or how they would truncate those calls?

Ximena Bernal: Yes, so that is really interesting, because we humans are introducing a lot of sensory pollutants. That's what we call them. So, for instance, noise, artificial at night, and we've been really interested in trying to understand how these affect communication systems. And for organisms that use acoustic signals, noise, for instance, can affect them. And there's a lot of work that has been done, a lot with birds and some with frogs. And we know that they respond, that birds in cities, for instance, sometimes they wake up earlier and call before rush hour when the noise is lower, and we are trying to understand what kind of responses they have. And we have long been exploring, especially traffic noise, more recently artificial at night, but I'm interested in how those come together to affect the species interactions. So, for instance, in one of the first times that we heard about it, we were looking at these frogs, and the frogs occur in the forest, but also in cities in Panama.

They can breathe in little bottles, and they can be by the sidewalk calling. And in cities, we have noise, and we have artificial light at night. So we're like, okay, how is this affecting these networks? And what we found is that in the city, the frogs are calling, they're fine. The numbers are equivalent to what we see in the national forest, but there are very few bats and very few frog biting mosquitoes. So the cities are safe heavens for them, and dual spec is good. However, when you look at females, female frogs, there are fewer females per capita in the cities.

I actually have a grad student that is going to go this summer to Panama to look at this. But what this has led to is corrosives in the cities, in which the number of males is the same, there are fewer females, but they're not eavesdroppers, and males produce more elaborated signals. So do you remember the wine and chalks? They're more likely to add chalks; they add a lot of chalks. And when you ask females, we can ask female frogs from the rural areas, from the cities, which calls you like better, the ones produced by males in the city or the ones produced by males in the forest? And they all prefer the calls produced by males in the city. So this was really funny. And actually, when this paper came out, we had a show, Saturday Night Live, that was like, "Males from the city are sexier."

And I'm like, "Male frogs, male frogs."

Fred Lawrence: So the work obviously is fascinating for its own sake. And part of the reason we do research in any field is to push back the bounds of knowledge, and to learn more about understanding the world that we inhabit, and of course, the world that we affect. At the same time, it's hard not to wonder about practical applications or human applications. And for most of us, when we think about frogs, as I said earlier, we have all sorts of associations, many of which are actually quite positive, either in the sense of warm early summer nights. There are not many positive stories about mosquitoes. So I wonder: is there anything in your work that would help us deal with the issues of not wanting to get mosquito bites?

Ximena Bernal: Yes. So I'm in this because I love understanding the natural world around this and how organisms function. But what I love is also this: I have always been a strong believer that basic science can generate unexpected effects that translate into applications. And I always hope, honestly, deep inside, that maybe that will happen to me. And I'm so excited, because I've seen it now over my career. So I was going to share two stories with you. So the first one is that we first started asking a basic question that is... We basically wonder how flies hear frog calls? And I'm like, how could it be that suddenly a fly, a mosquito, is hearing a frog call? How does that even happen? So we went on a long journey to try to understand their ears, and this has broadened our understanding of hearing systems in unexpected ways. But on that journey, the first mosquitoes that I was working with, they sounded too farish to find their host, the females, to find the frogs, but also for mating. So what happens with mosquitoes is that the wing beat is a bit annoying to humans...

Fred Lawrence: Yes, yes, yes, that's right.

Ximena Bernal: That actually is a beautiful mating song. So it's equivalent to our frog calls and our bird songs, and they get together in a swarm, and the male starts making these characteristic fly patterns in a specific way, and they all swarm in there, and the females come to the swarms, and then they hear each other. And what we show is that in our midst, the males are swarming, and then the females come, and they start interacting, and they actually adjust their wing beats in a way so they force the behavior-

Fred Lawrence: It makes the meeting possible. Extraordinary.

Ximena Bernal: So, as we were working on these wing beats for these mosquitoes that bite frogs, we started thinking, can we use the wing beats of the mosquitoes that bite us to set up traps? A mosquito

is a vector of many diseases, yellow fever, chikungunya. So many reasons for why we don't want this mosquito biting us.

Fred Lawrence: Yes, of course.

Ximena Bernal: And it's one that is relatively hard to trap. It doesn't fall in great numbers in the traditional mosquito traps. So we recorded the wing beats, and we developed a trap that we first tested in rooms, and it works well, and then in semi-natural conditions. And it's very effective; it works well. The catch-22, however, is how do we produce a stimulus that is effective at attracting the mosquitoes, but doesn't annoy humans? And we have a paper on this, and for a little bit, we're working on developing this forward, but as we interacted with more and more people, the main barrier became human annoyance.

Fred Lawrence: But what a marvelous example of how pure science research does, in fact, have applications, and why if we had limited our inquiry just to what we thought was going to be the applied work, we would've missed this altogether. And this is one of the classic cases we talk about a lot in terms of the case for pure science research, that limiting it just to applied research, it's not just that that deprives us of the ability to learn all sorts of interesting things. It actually turns out not to be the best applied research either, because we're missing the opportunity for the unexpected discovery, such as the one you're talking about.

In your own work, your professional life, in your professional career development, I know you've been a strong advocate for equity and inclusion in science, and particularly in addressing barriers that have been experienced by Latin American women in science. Can you talk a little bit about what your own thoughts have been and strategies have been in that regard of removing barriers and opening doors?

Ximena Bernal: Yes. Well, I appreciate the question, because I do feel that I was very fortunate, and I happen to be lucky enough to be given a chance. And I have really enjoyed having an opportunity in life to do science, because I love it. And I feel that everyone that has the interest should have the opportunity, as ability's widespread. And I feel that now more than ever, we need creative solutions. And those creative solutions come from anywhere, as long as we're able to listen to them. And one of the first, the main efforts that I think we have been pushing forward is even just starting the conversation, because sometimes we normalize so much certain behaviors and rules, invisible rules that, because no one talks about it, people normalize them and think that's okay when it may not be the case. So, a while back, we, for instance, wrote a letter in a journal called *Science* in which we were just raising awareness of how this is so ingrained in Latin American culture that even many times, we women may promote these exclusive behaviors and not support other women.

So it's only that it's coming from males, for men. And so, I think that the first important step is to talk about it. And for instance, I will go to... It was really interesting. One of the first conversations happened at a Latin American Congress in Ecuador, and at first, I was talking to these young students, and they were like, "No, I don't think this happens here."

I'm like, "Oh, okay." I'm like, "Well, maybe this is good news."

And then as we're talking about it, they're like, "Oh no, it does happen. It's just we were not aware."

And I'm like, "Hmm." So I feel that the conversation has changed, and awakening this is important, because that's the first step towards making changes. And since then, we and other people have been collecting data and kind of trying to see, well, what are the main barriers and how can we promote getting over those barriers?

Fred Lawrence: One of the things I always do on *Key Conversations with Phi Beta Kappa* is I ask our guests to help our listeners build their reading lists. What I would be grateful for is a couple of suggestions, some for people with some background in the field, but who would like to push their knowledge to a further level, and then for some for whom this is of general interest, they liked frogs, they were interested in the outdoors, but never really thought about this as a field and were looking for points of entry. So what could you do to help us build our reading lists?

Ximena Bernal: Okay. I'm going to start with a herp-specific. So Herpetology is the study of amphibians and reptiles. And as I said, I love being in the field. And I think that connection with nature and that experience of being a scientist studying nature is so unique and is so well encapsulated in a book that is called *Lost Frogs and Hot Snakes: Herpetologists' Tales from the Field*. And this is a series that was edited by Martha Crump, and really, you get to see the stories that are very short stories from herpetologists from around the world about how being in the field led them to new discoveries, or how important it was for them in so many different ways, and also the dangers. Doing field work can be dangerous sometimes, but also it leads you to unexpected discoveries. So it's all adventures that herpetologists go through from around the world.

And in the preface, I love it because well-known herpetologist, Ignacio de la Riva says, "Perhaps when looking back to the years and years of field work, we will realize that, albeit sometimes we did not find everything we expected or cherish, for sure we always met the very best version of ourselves. Field work forever."

And that just touches my heart, because I love being in the field with the animals.

Fred Lawrence: Beautiful, beautiful. Inspiring.

Ximena Bernal: And another book is, well, I consider myself a sensory biologist. And what that means is that I'm interested in understanding how organisms process, acquire, process information and respond to it. Ed Young did an amazing work, and he basically went all into the world in his book, *An Immense World: How Animal Senses Reveal the Hidden Realms Around Us*. And it's a great book about all the sensory worlds that we often forget about that are out there in nature. Last but not least, there's this book that came out recently, just a few years ago, that is called *Women in Herpetology: 50 Stories From Around the World*, and it's an edited book by Umi Arifin, Itzue Caviedes-Solis, and it basically puts together stories from women herpetologists from around the world, and it's beautiful. And the idea is to increase visibility of women herpetologists.

Herpetology traditionally has been a very male-dominated field, and it's all the stories of women working with amazing frogs, snakes, lizards, and everyone has a unique story from different parts of the

world. So if there are girls in your life or other women that want to see themselves in going into that path, this could be a source of inspiration.

Fred Lawrence: Well, and that goes back to this idea of inclusion beginning not just with societal programs, but with this kind of very basic awareness raising of possibilities. I know from your time with us as a Visiting Scholar this year that you not only shared your fascinating research, but your passion for the field, and I think that has been contagious on campuses. So thank you so much for your joining us this year as a member of the Phi Beta Kappa family as a Visiting Scholar on our campuses, and thanks so much for joining me today on *Key Conversations with Phi Beta Kappa*.

Ximena Bernal: Thank you so much for the opportunity.

Fred Lawrence: This podcast is produced by Phantom Center Media and Entertainment. Kojin Tashiro is the lead producer and mixed this episode, and Hadley Kelly is the Phi Beta Kappa producer on the show. Our theme song is Back to Back by Yan Perchuk. To learn more about the work of the Phi Beta Kappa Society and our Visiting Scholar program, please visit pbk.org. Thanks for listening. I'm Fred Lawrence. Until next time.

CITATION:

Lawrence, Fred, host. "How Nature Communicates Through Eavesdropping with Ximena Bernal" *Key Conversations with Phi Beta Kappa,* The Phi Beta Kappa Society, May 4th, 2026. www.pbk.org.

Produced by: