Ask A Biologist Vol 079 (Guest Arianne Cease)

Swarm Science

During a plague year, locusts can swarm over 20 percent of the world's landmass, affecting one out of every 10 people on the planet. Sounds bad – right? Enter biologist **Arianne Cease** who has been studying why these insects swarm and how to control them. Dr. Biology learns about her work and an interesting research area called telecoupling.

Transcript

Dr. Biology: This is *Ask A Biologist*, a program about the living world and I'm Dr. Biology. Let's talk a bit about grasshoppers. These are insects that are commonly found around the planet and, when you have a few of them, everything is OK. But when they number in the tens of thousands, there is a problem and one that has plagued humans for thousands of years. In fact, locust swarms have been documented by ancient Egyptians.

What is it about swarms of locusts that is so concerning? Well, they can wipe out a food crop in a few days. Put this in perspective. During a plague year, locusts can swarm over 20 percent of the world's landmass, affecting one out of every 10 people on the planet. Sounds bad, right?

Enter our guest, Arianne Cease. She's a senior sustainability scientist in the Julie Ann Wrigley Global Institute of Sustainability and an assistant professor in the School of Sustainability at Arizona State University.

Arianne's research has been looking at the ecology and the physiology of organisms; in this case, our grasshopper, and how humans can affect how much impact these insects can have on a particular region.

To do this, her work brings together different science disciplines, as well as many social components, to understand how the interaction between humans, plants, and insects affect crops. It involves an interesting new research area called telecoupling, a new word for me, and one that we'll explore today.

Welcome to the show, Arianne Cease, and thank you for visiting with me today.

Arianne Cease: Thanks for having me. I'm very happy to be here.

Dr. Biology: Before we jump into your work with grasshoppers, I want to first talk about these insects and the fact that they are both a problem and important for the ecosystems of the planet. In other words, grasshoppers are not all that bad.

Arianne: That's correct. Grasshoppers are very important parts of many natural ecosystems, particularly grasslands. They're very important for cycling nutrients. They eat bits of grasses and

other plants, and then they allow those nutrients to go back to the soil. They maintain high plant diversity in a lot of cases, and they're also a really important source of food for many different animals and organisms.

Dr. Biology: A world without grasshoppers would be...?

Arianne: Pretty bleak, I would say. [laughs] You would probably have situations, particularly in grasslands, where you might have some plant species becoming more dominant than we're accustomed to. They can help maintain the plant diversity.

We would also see a missing link in the food chain. You would have probably less predators, potentially less trophic levels.

Dr. Biology: You want to talk a little bit about trophic levels?

Arianne: "Trophic" just means, "eating." When you think about a food web, which may be familiar, we think about how all the organisms are connected at different levels. We have the primary producers, typically the plants, at the bottom of the food chain. Then we have herbivores that eat the plants, and then the next top up is the consumers which eat the herbivores. Then we have different levels of consumers.

Dr. Biology: We've got grasshoppers, they're not all bad, but we talked a little bit at the beginning of the show about how, when they swarm, we call them locusts, and they can really be damaging to crops. When you got started, was this what you were thinking of doing when you were getting into biology? What brought you to the world of grasshoppers?

Arianne: I was really excited about science and biology from an early age, then I got a degree in biology. I got really interested in how animals adapt to their environment, so the field called, "The Environmental Physiology," or a combination of ecology and physiology. I was really fascinated with that, but I wanted to understand better how the rest of the world lived.

I was really interested also in international development. I wasn't quite sure what I wanted to do when I graduated with my undergrad degree in biology, so I decided to join the Peace Corps. I was a sustainable agroforestry extension agent in Senegal, which is in Africa. It's actually the westernmost country on the continent of Africa.

I arrived in Senegal in 2005, which was just at the tail end of one of the last three large desert locust plagues. The desert locusts had come out of its typical recession home in the Sahara, and it had invaded down through Senegal. I arrived again in 2005, it was just on the tail end of that.

Come the dry season, another grasshopper who's not necessarily a locust, but a grasshopper ascended on the village where I was living. They ate everything. If you read any stories about locusts or talked to farmers, a really common quote that you'll hear is, "They ate everything, there's nothing left."

That made quite an impression on me. Living in a subsistence farming community, they welcomed me into their community, in their homes. We're working together to try and implement three technologies into their family compounds and into the aquaculture.

The biggest problem that I found that the farmers were facing the year I was there, at least, was these grasshoppers. After I finished the Peace Corps, coming back to the US, I was so excited and interested in biology, but I really wanted to pair it with something that would have a global impact. It was a late bob moment when I realized that locusts were at the pathway to do that.

Contextually, go back to the community where I was working in Senegal, and see if we can come up with some more sustainable, creative solutions to grasshopper and locust plagues.

Dr. Biology: You've got the bug, so to speak, in Senegal. You got back into biology as a graduate student, how did you pick your lab? Did you know that you were going to be able to do what you wanted to do when you were out searching for your school in the lab?

Arianne: I would like to, maybe be able to say, "Yes," because I have a very clear vision and a clear pathway, this is exactly where I wanted to go. It wasn't necessarily the case. I came back to the US, to be honest, I was a little bit at a loss for what to do next.

I knew I was really excited about biology, and understanding how organisms adapt to their environment, but I really wanted to incorporate all these other things that I want to incorporate, like global impact and sustainability.

I worked for a couple of sustainability organizations in Portland, Oregon, where I lived for a year after I was a Peace Corps volunteer. At that point in time, I didn't actually see a clear pathway for combining all of these interests. So, I decided...I'm pretty good at biology, and I really, really enjoy it, so I'll go into that field, and see where I can go from there.

I did an extensive search, and one of the things I Googled was environmental physiology. One of the first pages that popped up was actually Professor Jon Harrison, who's at Arizona State University. I sent Dr. Harrison, along with a number of other professors, emails saying where I was coming from and that I was interested in working in a lab.

He responded immediately and very positively. When I came out and asked you for an interview, one of the things I very distinctively remember him saying during the interview, we're walking through the juncture where the Global Institute of Sustainability, now is that building, I think he had it on his mind because he knew that was going to become The Institute of Sustainability.

He turned to me and he said, "You've done all of these other things, you were a Peace Corps volunteer, you worked with a number of sustainability organizations, how are you going to incorporate sustainability into your PhD?"

That was one of the liable moments. For some reasons, it hadn't occurred to me that I could do that. Hearing him say that, it really firmed my decision to come to ASU, and to join his research group.

Dr. Biology: Let's talk a little bit about your research, and what you've discovered.

Arianne: I started out wanting to study locusts and migration, so I went out looking for locusts to study. I ended up in China because I met a good collaborator, and there was a NSF fellowship program that was sending graduate students to China, at that time. That's how I got my start, studying the Mongolian locusts in northeast China.

I went out thinking, maybe I just need to understand what drives outbreaks. If we understand "What are the environmental factors that trigger these outbreaks in development of migratory swarms," that kind of thing, at least, maybe we can have a better idea of when they're coming, so we could be better prepared.

I was really thinking of it as a solely biology project and research program. Then pretty quickly, I realized that there was a strong human element involved. Specifically, wherever we went to look at locusts was in these fields that were heavily grazed by livestock.

It was really apparent from the start that there was a strong connection between land use and locust outbreaks because that's where we always found them.

We had known that for some time a number of other great scientists have described this pattern, but we didn't really know why. We didn't know why in particular for the Mongolian locust. So, then we set out to answer that question, "Why do locusts prefer these areas?"

One of the things I noticed early on was, we would be collecting locusts in a heavily grazed field, and adjacent, there would be fields that would be more protected, so they would have either no livestock grazing or very low livestock grazing. To me, it looked like a lot of lush, green, beautiful grass, very nutritious, there's a lot of it.

The heavily grazed fields, of course, there's less grass, it looks kind of poor quality from what we might think of as a low-quality grass. I thought, "Maybe they prefer this open habitat, but why don't they go, jump over the fence to go, eat some of these lush looking grass on the other side?" I almost never found locusts eating grass on the other side, that particular species we're looking at.

There were other grasshoppers species, of course, over there, a great diversity of them, but none of these locust that has outbreaks and causes agriculture and economic damage.

Dr. Biology: When you think about it, I would think the same thing. Why would an insect not be picking a better quality plant? If you had a hypothesis if you're going out, and you'll look to those two plots, you're going to say, "Which one would the insects go to?" You'd think, just like you said, you would go to this lush area. But, that's the neat thing about science – right? It's the unexpected that holds a lot of clues.

What's going on with your clue about what was going on?

Arianne: At the same time, we're running a number of other experiments where we collected a bunch of locusts. We put them in these field cages. The cages were placed over grass that had been either fertilized with nitrogen or unfertilized. Our hypothesis was that if we feed them sort of high-quality nitrogen-fertilized-grass maybe they wouldn't migrate because maybe they're migrating because they have poor resources.

So we had this experiment going on, and the results of this experiment were a bit puzzling, particularly for me at the time, which was most of the locusts that were fed the nitrogen-fertilized grass died. I was thinking I did something wrong, so I was looking through all the methods. I thought maybe there was still fertilizer residue, maybe there's all these other things going on. Then, finally, my advisor threw out the suggestion maybe high nitrogen plants are just bad for them.

That sort of fit all the puzzle pieces together because I knew from other research that the plants in the heavily grazed fields had a lower nitrogen content because they're growing in these soils that the topsoil has been lost. They're growing in soil with a low nutrient content, so the plants are going to have a low nitrogen content themselves. Then it all just clicked.

We raced back the next summer, did a bunch of experiments, all kinds of host plant choice tests. We made up specific artificial diets with different levels of proteins and other nutrients in them, typically a low protein, high carbohydrate diet, and found that they preferred that diet, and they performed very well on it.

They had a high survival, they had fast growth rate, all these things that are associated with an increase in population abundance when they have access to this optimal nutrition.

Dr. Biology: I know that kids and people in general just really think of a lone scientist. Maybe there's a lab person in there and a technician or something, but it's always "the" scientist. The problems we have today are really big problems, and they're usually broader and bigger than what any one person can do. So what does your team consist of and who are the players that you would put on your dream team?

Arianne: Absolutely, and I think dream team is a great analogy.

On my dream team, we have a diversity of biologists, we have an insect physiologist, we have a neurophysiologist, we have an ecosystem ecologist. We're also working with a number of plant biologists and soil scientists. Then we also need to have disciplines beyond the natural sciences, sciences, of course, because humans are a very important component of pretty much all systems now. Then we have a bio-economist.

Beyond the academics and the researchers, of course, these problems are based in reality, and so we need to be connected with organizations and people that are on the ground, that are not just working at universities. Then, a really important component is the communities themselves.

We work mostly with farming communities. They're grazing livestock. In Senegal, we're working with villages where they're growing millet and peanuts. The farmers and ranchers themselves are also an integral part of this team and an integral part of finding solutions to some of these challenging problems. This one in particular, we're trying to understand locusts and understand the whole system.

Dr. Biology: Are parts of the world more likely to suffer from locust swarms?

Arianne: Locusts are found on every continent outside of North America and Antarctica, so they really have an impact [need a T]all over the world. One of the reasons we don't hear about them so much in the US is we don't have a strong locust species. We did, around the late 1800s. It was called the Rocky Mountain locust, and it wreaked all kinds of havoc on settlers in the region, and then it quietly went extinct around 1900.

Dr. Biology: That's a whole other story we'll have to talk about at some point.

With your team sport, science, there's this new area of research called telecoupling. I'd love to learn more about telecoupling. It sounds like it's made for the modern age.

Arianne: It is. "Tele" just means distance or far, and "coupling" is obviously connecting two or more things. Telecoupling is when you have two or more regions or places or human communities that are seemingly far apart, but they are connected by something in nature or policies or markets or something like that actually makes the distance between them seem pretty small. So they can have a pretty big impact on each other – even though the distance is far.

Dr. Biology: When we're talking about distance, we are really talking about distance, like miles, kilometers.

Arianne: Yes, kilometers or sometimes on the other side of the planet.

Dr. Biology: When you do your work, you've talked about the scientist and the social scientists that you bring together, but my understanding is there's another very important component that you've found in your research. This has to deal with the community.

Arianne: We do have our science team, but another equally important component of these teams is working with the communities themselves, the human communities that are impacted by locusts and that are part of the system. Also, working with other institutions, like government agencies for pest management, and other agricultural agencies. We have partners locally with all of these different types of folks that are working on the problem from different angles.

Dr. Biology: The overgrazed lands , have they always been overgrazed or what's changed that we're overgrazing the lands?

Arianne: It's a couple factors. One is just a simple increase in human population. You have more people in the landscape, and the land gets used more intensively.

Another change that we have is when communities and countries become more affluent; they're able to increase their meat consumption. It's usually one of the first things to change. In order to do that, we need to have more livestock, so we have a higher density of livestock going onto the landscape.

Dr. Biology: They want more livestock, and that actually brings in more money, but it can increase the likelihood of having a locust outbreak.

How do you change the behavior? How do you decouple that so that the farmers and the ranchers understand the importance of how they're using the land and still keep the economic role in focus so that they don't end up not being able to advance themselves economically?

Arianne: It's complex and challenging, and I think it's really exciting to think about addressing a problem like this because there are many different stakeholders and different things that have to be considered. We've gone in, and we found a biology mechanism underpinning locust outbreaks.

The way to understand this and the way to think about how to address this complex issue with all these different player, I think the best way is to take a step back and think about the whole system. We have these diagrams of farmers and livestock markets and policy and locusts and sheep and grass and soil and all these different things and all these arrows connecting them all.

Going back to telecoupling, all these things are connected. They're connected locally, and then they're also connected to other regions.

So why are farmers having more livestock? Well it's because there must be a demand for it. So there's demand in the market for livestock and, at some level, it must be supporting their livelihood. They're in many cases just trying to feed their families and get by.

So how do you go talk to a farmer and say, "Well, actually can you not grow as many livestock because it's creating what we call an externality," which is an unintended problem that comes from managing the land in a certain way locally. If you have overgrazing locally, it's a problem locally because we degrade the landscape, and we create locusts locally, but then it's also a problem distantly because the locusts, of course, can migrate and affect croplands and grasslands in distant places. So how do you connect all those dots and find a good solution?

Firstly, again, it's to understand the system and how these different things are connected, and then we can start to think about how do we optimize farmer livelihood and grassland sustainability and decreased probability and severity of locust plagues are the three main things that we're thinking of. One way is actually going back to the physiology of the organisms involved, which, again, brings me back to the roots, how do animals and their physiology, how do they adapt to the environment?

If we look at the locust, we know that locusts prefer and perform best on these low proteins, high carbohydrate grasses. If we go to the sheep, we'll find that the sheep actually prefer a higher protein grass, and they do better on a higher protein grass.

We know that land management, the intensity of grazing in this case, can be a dial for us. So we can turn that dial, and if we turn that dial a little bit towards maybe more moderate grazing instead of overgrazing what we create is a grass that's optimal for growing sheep and not optimal for growing locusts.

Under that scenario, if we decrease stocking rates slightly, we end up with sheep that grow bigger and faster. They have, on average, more lambs per year. Sheep can have usually one or two lambs, so oftentimes they'll have multiple lambs, and the farmers can get a high dollar for them at market because they're a higher quality product.

Actually, if we decrease grazing rates slightly, that will increase farmer household income. The reason we know this is because one of our partners is at the Inner Mongolian Agriculture University, and they're working with 1,000 farmers to implement these practices. They found that this is a viable, sustainable way for farmers to continue grazing livestock, continue maintaining their livelihood, increases grassland sustainability, and also decreases the probability and severity of locust plagues.

Dr. Biology: You can see the impact rather quickly. That's the interesting thing about it with humans. We change a certain behavior. We can have a real quick impact.

Arianne: That's exactly right. In particular, with our studies on locusts, we became quickly interested in what are the dials that we can change. Land use is one of those things. It's a bit more difficult for us to think about controlling climate which is also a really important variable for locust population dynamics and determining whether or not we have a locust plague, but that's out of our

control. How we use our landscape is something that is potentially under our control, and it's really powerful.

Dr. Biology: With all of your work you've been doing, it sounds like you do an awful lot of traveling.

Arianne: Yes.

Dr. Biology: Is this one of the perks of being a biologist in your area?

Arianne: It is. Traveling around the world is definitely one of the perks of being a biologist and being a sustainability scientist, but I think more than that is being able to really connect and work in communities in these different countries around the world.

Dr. Biology: With all the travel, has there been an unexpected or funny event that you could share?

Arianne: Traveling to Senegal recently, we had found some pleasant surprises.

We went to set areas where we would be doing fieldwork for the next several years. We worked with the National Plant Protection Agency. They're responsible for locust management. They helped connect us with regional folks also thinking about this issue. Then, through those people, we learned of local village leaders.

It was me and one of my students from ASU, an undergraduate researcher, and also my lab manager. We were going around to these different communities and trying to see if people were interested in working with us on this project, and we weren't sure what we were going to find.

We would go in, and we would meet with the regional agricultural leaders and then eventually the village chiefs, and it was a tremendous response also immediately. We would show up. Oftentimes, people wouldn't know we were coming. Sometimes we would be able to call ahead and let them know, but oftentimes people had no forewarning.

We showed up. We told them our story. I told them I was a Peace Corps volunteer. My student, Baoding, is originally from the Gambia, so he's obviously got a lot of experience in that region, too. The Gambia is inside of Senegal for reference.

So we would show up. We would meet with the village chief. They would tell us about some of the challenges they were faced, and then they would call a meeting, and we would have farmers come from two or three villages over. In one case, we all squeezed into a one-room schoolhouse, which was endearing to see grown farmers squeeze into kid's desks.

Their community organization was really impressive. They had a lot of really great ideas. They were very good at articulating what their main problems were, and the Senegalese locust was definitely chief among them, so they were very excited to work with us.

They said that they knew we were serious for a number of reasons. One is our prior experience, so my experience as a Peace Corps and Baoding having grown up in the region. But they also felt like we have a good grasp on the problem because we came in talking about the specific Senegalese

locust, and they said, "Oh, we know that you know the area, and that this is a major problem for us."

So we set out to select just 10 farmers to work with us because we would catalogue all of their land use, we would ask them a lot of questions, we would go out and take a lot of samples, like soil samples and plant samples and study the locusts on their property and that kind of thing. It's all pretty intensive, so we were aiming to select about 10 farmers from each of these communities we were working with. We had a schoolroom full of maybe 40 or 50 farmers, and all of them wanted to be involved in the project.

We left the decision up to the leaders. We had a few specifications, like they had to be distributed and that sort of thing for the science, but we left the decision of who would be the 10 farmers up to the leaders, and everyone else was pretty disappointed that they didn't get to be involved in our project.

We ended up taking down everybody's name and phone number, so we'll be able to involve everyone in the social science aspect of the project, which is calling and doing phone surveys and trying to understand better how people interact with their environment.

That was really a pleasant surprise. We went in not knowing if people would want to be involved at all to having this really overwhelming response.

Dr. Biology: Marvelous, marvelous. I wish we could get that on a lot of things.

Arianne: Absolutely.

Dr. Biology: I promise not to embarrass you, but I did want to bring up a recent award that you have just gotten from "Popular Science." They do this once a year, and it's called "The Brilliant Ten," and you are one of the brilliant ten. They actually say, "'Popular Science' honors the brightest young minds reshaping science, engineering, and the world." So I want to say congratulations.

Arianne: I don't know that I would use the word brilliant, but I'm certainly thrilled to be able to do what I do. I feel very lucky, very fortunate to have had the opportunities that I do have. Of course, it's a tremendous honor to receive the award.

Dr. Biology: Not to embarrass you, it wasn't really the reason for that. The whole idea is that science is not out for the awards but, with this, it does elevate this discussion we just had about telecoupling and this new area of research. I think that in itself is really impressive.

With that, it allows me to move into the last part of our show, and the last part of the show is where all my guests answer three questions. So here we go.

When did you first know you wanted to be a biologist?

Arianne: The first a-ha moment was when I was a freshman in college, and I thought I wanted to go be a broadcast journalist because I wanted to see the world, and I wanted to understand a lot of things and meet a lot of cool people. For some reason, broadcast journalism jumped out at me as a good career path.

I started out as a freshman on that career path, and I took a biology class just for fun and quickly realized that I loved biology or remembered that I loved biology, and that was really where I wanted to focus.

Dr. Biology: You're just starting out your career, but I'm going to take it all away. So you don't get to be a biologist. You don't get to be a scientist. Since you already gave me an introduction that you might be a broadcast journalist, I'm going to take that away from you because I want you to stretch here.

What would you be or what would you do if you could do anything?

Arianne: That wasn't a scientist or a broadcast journalist. Gosh, I don't know. That was my plan B. [laughs]

I don't know – I think I've thought a lot about how I could apply science in a lot of different ways, so I thought about a lot of different pathways outside of academia. I think if I wasn't a scientist and I wasn't a journalist, I think I would be doing something with international development.

Dr. Biology: Back to the Peace Corps route.

Arianne: Exactly, which I'm very lucky in my career that I get to combine a lot of those together.

Dr. Biology: Did you find the Peace Corps was a really great experience and somewhat of a grounding point for your next phase of your development?

Arianne: Absolutely.

Dr. Biology: Final question, what advice would you have for a young biologist or perhaps someone who has always loved looking at, say, grasshoppers and wants to change their career?

Arianne: I think this advice is maybe a bit trite, but I would say focus on what you think is most exciting and figure out a way to make it happen. It's not just to say, "Follow your passion," but I think that if you're really excited about something and you think it's important, then you're going to work very hard at it. It's going to be easier for you to explain to other people why it's important.

So I would say find that thing that you think is most exciting and see if you can't figure out a way to get from point A to point B or point C or whatever to make it happen.

The other thing I would say is find good mentors.

Dr. Biology: Ah, very good. That's at all stages, right?

Arianne: Absolutely.

Dr. Biology: Arianne Cease, thank you for visiting with me today.

Arianne: Thank you for having me.

Dr. Biology: You've been listening to *Ask A Biologist*, and my guest has been Arianne Cease, a biologist and assistant professor in the School of Sustainability at Arizona State University. For

those who might like to explore about Arianne's work, we'll have a companion story on the *Ask A Biologist* website, and we'll have the link to the story from this podcast page.

The "Ask A Biologist" podcast is produced on the campus of Arizona State University and is recorded in the Grassroots Studio housed in the School of Life Sciences, which is 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 askabioloist.asu.edu or you can just Google the words 'Ask – A – Biologist'.

I'm Dr. Biology.

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