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SPEAKERS
Chase Anselmo, Matthew Zipple, Eleanor Caves

Eleanor Caves 00:00

I am never going to go to outer space because that idea completely terrifies me. But I think this is as close as I could ever get to like exploring that kind of unknown. What are the sensory and perceptual worlds of these animals? They're, they're probably just a different reality than, than our own. And I think that's just so exciting.

Matthew Zipple 00:31

Hello, and welcome to the Animal Behavior Podcast. I'm Matthew Zipple. In this episode, I speak with Dr. Eleanor Caves about her work in sensory ecology, especially her work studying the mutualism between cleaner shrimp and their clients. Eleanor speaks really cogently about the goals of sensor ecology, and why it is so important and allowing us to understand how and why our study organisms do the things that they do. We also talked about work life balance and overcoming challenges in academia. Eleanor and I have been friends for a long time. So I was able to ask her about things that I might not have been able to ask someone that I knew less well. As a result, this episode ended up being on the longer side, but I think it's worth it. And I hope you do too. Let us know what you think at animalbehaviorpod@gmail.com. My guest today is Dr. Eleanor Caves, a Marie Curie postdoctoral fellow at the University of Exeter in the UK, and a soon to be assistant professor at the University of California Santa Barbara. So first of all, Eleanor, congratulations on your new position.

Eleanor Caves 01:37

Oh, thanks. I'm really excited.

Matthew Zipple 01:40

I imagine that negotiating and preparing for a new job from 1000s of miles away is a challenge under any circumstances. And throwing in a global pandemic didn't make it any easier. So what has that process been like for you?

Eleanor Caves 01:54

To be honest, it's been a big learning process in in just being able to sort of let go and not have a lot of control, I think, you know, I. I was offered this job before this fellowship even started and I pictured myself moving to England and from afar, just kind of dictating what I wanted my future lab to look like recruiting students flying back a couple of times to check on everything. And in the end, what's happened is that there's just a lot of uncertainty around all of those things, from renovations to student funding at universities right now. And so there are a lot of questions I have that I just can't get answers to. And that's only because nobody has the answers to those questions. It's been an exercise in learning to let go of some control and re-envisioning what I think it will be like to start my own lab, but also at the same time realizing we're gonna get through this and I am going to start my own lab, and also learning that there's a community of assistant professors and other junior faculty at Santa Barbara that have been great throughout the whole uncertain process. And I'm really excited to join that group.

Matthew Zipple 02:56

Before we get into the specifics of your research, I want to start with a concept that you wrote about in 2019, because I think it will give listeners the perfect context to think about the rest of your work. We'll put the article in the show notes. It's titled Von Uexküll revisited: Addressing human biases in the study of animal perception. So who is Von Uexküll and describe for us his idea of the umwelt?

Eleanor Caves 03:22

Yeah, so Jakob Von Uexküll, the Baron Jakob Von Uexküll was a German aristocrat and biologist, and in the early 1900s, he used this term umwelt, which is often directly translated as something like the self centered world. But what he was using it to mean was the entirety of an organism's sensory or perceptual experience. So he basically did a bunch of early experiments on the sort of behavior and sensory capabilities of animals like sea urchins, and jellies and ticks. And those experiments convinced him that animals could occupy different umwelt, even if they inhabited the same environment and as a result of differences in their sensory physiology, because the the sensory system is an interface between an organism and its environment. And so what's transduced by the sensory system allows an animal to have a perceptual experience of its environment. And so differences in that sensory physiology might translate to differences in the perceptual experience.

Matthew Zipple 04:21

Okay, so let's make this concrete. Let's say for the median human observer, the umwelt is going to be I'm guessing, primarily made up of visual stimuli with some auditory stimuli thrown in there. I mean, am I right here? Can you give us a sense of what a human umwelt is like, so that we can think about what some other animals umwelt might be like?

Eleanor Caves 04:42

Well I... that's an interesting question. I mean, in a certain sense, that's more of a philosophical question then the question we can answer with biological experimentation, right? Like I, it's an interesting field, I guess to be in because I can't even tell you what your umwelt is like, let alone umwelt of something like a cleaner shrimp but for the sake of argument, yeah, humans are highly visual animals, right? We rely a lot on our vision, we have really pretty, pretty good visual capabilities, we perceive a lot of detail. We have good color vision, we look at things before we we interact with them with a lot of other senses, I suppose we don't often begin by smelling something or by touching it. So yeah, maybe I'm biased because I'm a visual ecologist. But I would say that we're highly visual animals. Whereas by comparison, Von Uexküll has this famous assertion that a tick, the umwelt of a tick comprises only three things and that's the sun on its skin, the smell of butyric acid emanating from a mammal and the temperature of mammalian blood, and those are the only stimuli it perceives and those the only stimuli that that matter to it. That's probably an oversimplification. But I think what his work is particularly interesting and reminding us, which is something we can we can really afford to be reminded of now, as we start to expand animal behavior to more taxa. His experiments really show that these umwelt don't necessarily need to be very complex, nor do they need to be very much like our own to be perfectly functional for a given organism.

Matthew Zipple 06:10

Right. So let's push on that idea a little bit. One of the points that you make in that article is that we, as human observers, might assume that our umwelt is the same as that of the animals that we study. But the point of the article is that, you know, not only is that not always the case, but in fact, it's probably never the case. Right? So tell us a bit more about why that is. And maybe give us an example of how we can draw the wrong conclusion if we don't consider our study organisms sensory experience.

Eleanor Caves 06:42

Hmm, yeah. Okay. So the first part of that question was tell us why that is? Well, there's just a huge diversity of sensory capabilities in the animal kingdom. And full disclosure, I primarily know about visual capabilities. But we know that this is the case for other sensory modalities as well. But for example, with visual capabilities, we know that there are differences in how animals perceive literally every aspect of a visual scene, right. So we often think immediately of color vision, this is the most famous example of, of ways that animal vision differs from our own. But you know, there are animals that can see ultraviolet light, there are animals that can see polarized light, there are animals that cannot see as many colors as we can. And it's really hard for us to imagine what that experience might be like, you know, what, what does it color look like that we can't even see what what does ultraviolet look like? Do animals discriminate different shades of ultraviolet? Or is it just ultraviolet, but color isn't the only aspect of visual scene, there's spatial detail. And in that sense, humans are sort of up near the pinnacle of sensory capability. So visual acuity is the ability to perceive detail. And humans have some of the finest spatial vision in the animal kingdom, from us on down acuity ranges over at least four orders of magnitude. So most of the study organisms that we have that people study will not perceive spatial

detail the same way we do. And I guess, it's only fair to point out that we can draw the wrong conclusions from not considering this by using an example from my own work, I won't critique anyone else's work. But I started my PhD, fully intending to study these animals called cleaner shrimp. And they're tiny little tropical shrimps, they are covered with these beautiful spots and stripes and color patterns that are very fine. And they live in groups, they clean in groups, and they interact with coral reef fish called clients. And it just seemed clear to me when I started my PhD, that those color patterns must function for some sort of interspecific signaling purpose, maybe it was when they're in the group, they can assess, you know, species ID, or aggressive signals or something like that. But the first project that I did in my PhD was looking at their visual capabilities. And what we found was that they are completely colorblind. So they don't perceive any colors at all. They live in a sort of monochromatic, maybe a grayscale world, or just green scale. And their acuity is really shockingly low, so that even from a distance of only a few centimeters away, they can't resolve each other's color patterns. So that's an example of how, you know, I probably could have started performing behavioral experiments making the assumption that these were signaling color patterns. And I don't know how I could have interpreted those results. But right away, it sort of set me on this path of thinking about this is a whole group of animals with these beautiful color patterns that they can't even themselves perceive. So who are they for? And that sort of inspired my my research on cleaner shrimp ever since.

Matthew Zipple 09:44

We're going to focus on cleaner shrimp in just a moment. But for now, I want to stay on this idea of spatial acuity. You've argued that acuity specifically is especially important if we want to understand the importance of apparent signals. In a TREE (Trends in Ecology and Evolution) paper that you wrote, you give several examples of how understanding a receivers acuity shapes our understanding of the function of a color or structure of an apparent signal from a producer. One of the examples that I found really compelling is this idea that a predator might want to use a signal to make itself highly visible to non prey animals while still being invisible to prey. Can you describe that idea in a bit more detail?

Eleanor Caves 10:28

Yeah, so this is an idea that we were fleshing out with examples of jellyfish tentacles, and then web stabilimentum in spiders. This idea kind of originated with a journal club that I was attending at the time with Stephen Nowicki, who is a professor at Duke. And he wrote a paper a long time ago, that I think was in Science or Nature, looking at like, these web decorations that spiders put on their webs, because they are a bit of a mystery in that a web is a prey capture structure, right, it should work best if it's invisible. But a lot of spiders decorate their webs with these like zigzag silk patterns. And people have asked sort of repeatedly, for several decades, what is the function of these of these web decorations, one of the ideas that has come up is that they might be there to warn something like a bird of the presence of this web, because a bird is not the intended prey of a spider. But it is something that's large enough that if if it just goes crashing through the web, because the web is invisible to it, it could cause a lot of damage to the web. So it should be beneficial for the spider then to create something that warns a larger animal like a bird, that a web is there. And actually, we get a really similar thing in jellyfish tentacles, which a lot of them are highly pigmented, which ought to make them a lot more conspicuous to the intended prey. And again, it's a pre captures structure, so it should work

best if it's invisible. And this idea came to us when we were writing this TREE paper, because one of the things that's so cool about acuity is, it's highly correlated with eye size. And because eye size is itself tightly correlated with body size, it's correlated with body size. So we tend to see high acuity in larger animals that have larger eyes. So it's, it's actually a consistent way by which you could signal to one trophic group, but not another, right? Because you can be fairly confident if you're if you're an animal, that you could create a structure that's visible to large animals, because they have higher acuity but not visible to smaller animals because they have lower acuity. And I can't think off the top of my head, although maybe some listener will have an idea for us of anything else, any other signal trait that you could manipulate in a way that would be so consistently visible to one trophic level, but not another. In that TREE paper these are just hypotheses, we hope people will go off and test them. So we don't have any evidence that that's the case. But I do think it's likely that acuity is a really under explored potential private communication channel.

Matthew Zipple 13:21

Let's talk now about cleaner shrimp. First of all, what is a cleaner shrimp? Tell us a little bit about their natural history.

Eleanor Caves 13:27

Yeah, so a cleaner shrimp is like a dental hygienist on a coral reef. They live at a set location which we call a cleaning station. And then fish which we call clients come to the station pose nearby and then allow the shrimp to climb on. The idea then is the shrimp picks ectoparasites off, maybe cleans wounds, cleans away dead skin, etc. There are a lot of species of cleaner shrimp, several dozen at least around the globe across a couple of families of of shrimp, many different genera. So it's a pretty diverse group in the shrimps, and they kind of fit a lot of different ecology. Some of them are obligate anemone dwellers, so they live on a host anemone and that's their cleaning station. Some live in crevices quite deep. There might even be nocturnal cleaner shrimp. So it's pretty diverse group but they all basically serve this same function where they interact with client fish, and supposedly are eating off ectoparasites.

Matthew Zipple 14:30

Alright, so let's talk about the shrimp side of this mutualism. How does a cleaner shrimp know that a client wants to be cleaned?

Eleanor Caves 14:39

I can really only speak to the one, to one species at this point, right. But what I worked on for my PhD is a Caribbean species called Ancylomenes pedersoni. And what we tend to see in nature when cleaners are interacting with clients in this species is that a client will approach the anemone. The first thing that the cleaner shrimp will do, it has these long white antennae and it will whip them around. And then we see that the client fish will then pose in the substrate nearby. So a pose in this case is really just going very still in the substrate next to the station, they'll often flare out their opercular fins, open their mouth,

that kind of thing. And some of the work that I did during my PhD, was showing that this antennae whipping motion by the cleaner shrimp appears to be a signal of intent to clean. So as a client approaches the station, if the cleaner whips its antennae, there's an 80% chance it's then going to go on to clean. Okay, but what do you do in the 20% of interactions where the cleaner shrimp does not whip its antennae? Well, in that case, what we found is that once clients have posed, they can change color, and they'll rapidly change to this darker morph. And that seems to be a signal by clients that they really do want to be cleaned. And what we see is that clients that change to a darker morph at that point in time, triple the likelihood that they'll get cleaned. So to answer your question more simply right, what we see is that in most cases, it seems sufficient if a shrimp wants to clean that all a client has to do is posing the substrate nearby. And that's enough to say I'm here to be cleaned. But if a cleaner shrimp hasn't already indicated that it's intending to clean or that it's going to clean, then the clients do have another trick up their sleeve, which is they can do this color change. And that seems to then maybe really reinforce like I am I am here to be cleaned. Can you clean me? Or maybe it's? Yeah, it's some kind of signal directed at the cleaner, which then can induce cleaning.

Matthew Zipple 16:46

There are wonderful videos of these interactions that you've taken that we'll link to in the notes. And in these videos, you can see cleaner shrimp cleaning inside the gills and the mouths of these predatory fish. So do cleaner shrimp treat all clients the same or do they take extra care with a predatory client?

Eleanor Caves 17:05

So there is this pattern sort of emerging across several cleaner shrimp species that in fact they don't treat all clients the same. And the work I've done on how cleaners treat predatory clients is in a different species called Lysmata amboinensis which lives in the Red Sea. It's the same species that is Jacques in Finding Nemo like they'd actually do a pretty good job with him. It's a very accurate looking cleaner shrimp. And I should mention that this is work that I did, really in collaboration with Catherine Chen, who is now a graduate student at UNC but who was an undergrad at the time. And what we found in Lysmata amboinensis, they have these white front legs, and when clients approach their station, they put their legs together and rock them back and forth. But we really only see cleaner shrimp leg rock to fish that are potential predators. So this is fish that are known to include in their diet crustaceans that are roughly the same size as cleaner shrimp. They almost never do this leg rocking thing to non predatory clients. So it's it's almost like waving a white flag, right? If someone has arrived at your station that poses a potential risk to you. Maybe it's especially important to wave your white flag and be like, I'm a beneficial partner, don't eat me. I really am a cleaner shrimp.

Matthew Zipple 18:28

And thinking about cleaner shrimps really very limited visual capacity. How is it that they know predatory from non predatory fish? Do they just rely on body size?

Eleanor Caves 18:42

So body size is definitely a factor in that we see a positive correlation between body size of the client fish species and percentage of the time that that species gets cleaned. But you're right we know from their acuity that it's highly unlikely that they are you know, finally parsing the difference in you know, a matter of millimeters or centimeters. So between different fish species. So we did another experiment to try to get at this question, you know, how are they actually evaluating when to leg rock or not. And this is just about the leg rocking behavior, which we're using as a proxy, I guess for whether or not they consider a species to be predatory. But we brought shrimp back to the lab, we put them in a little tank and then we would lean an iPad against the side of the tank and show our our shrimp what we call synthetic clients which are just rectangles, triangles and circles on a screen. And we had black rectangles triangles and circles and white ones. And what we saw was that the cleaner shrimp were leg rocking a lot more often to the black shapes than the white shapes. But that doesn't mean that they think that dark colored fish are predatory because something else was going on. You know imagine you're a shrimp in a little tank and you're watching an iPad. Yeah, imagine. So we have a gray background, and then a white shape comes on the screen, that raises the overall light level in the tank. Whereas if you go from a gray background to a black shape moving onto the screen, you get a decrease in overall light level in the tank. So to disentangle this, we then created another set of slides that we showed our shrimp that just went from a plain gray background to either a lighter shade of gray, or a darker shade of gray, to calibrate it to cause the same change and in light as those white and black shapes. And what we saw was that their responses to black shapes were indistinguishable from their responses to just a darkening overall in light level, meaning they respond at the same rate with leg rocking. So what we think and this is potentially a little bit speculative. This is a species that lives in a crevice and client fish approach the crevice to get cleaned. If a giant fish approaches your crevice, there's going to be a bigger drop in light level than if a smaller fish does. So, you know, it's still size, I think that they're evaluating but they're not doing it by actually evaluating the size of the fish, they're doing it maybe by the overall change in light level that that fish causes when it approaches.

Matthew Zipple 21:17

So they clean predatory fish less often, but they still clean them. What's to keep the client from eating them? Do the cleaners taste bad? Is it something else?

Eleanor Caves 21:26

Well, we don't have any evidence that they taste bad. I have fed a lot of chopped up cleaner shrimp to five different species of tropical fish, and they gobble them right up. And there don't seem to be any ill effects after. That's not entirely conclusive, right, because these are shrimp that I had in the lab for a while, and then they were frozen. So you know, for the ones that live on anemones, for example, if they are picking up some protection, some nematocysts from their anemone that might not have existed anymore after they'd been in the lab for a while. And so if they were a bit distasteful, maybe that had gone away, but I think it's unlikely that they are toxic. So yeah, what what is to keep them I think, the idea is, it's a cost benefit trade off, right. And for a long time, cleaning was painted as this rosy mutualism where cleaner gets a meal, a client gets cleaning, boom, everybody's happy. But what we're

finding is that it's a lot more context dependent than that, right. So the the outcome of a cleaning interaction can range anywhere from mutualistic to basically parasitic on the part of the cleaner, taking healthy tissue and so on. But we almost never see clients eat the cleaner. So it must be that having cleaners around and you know where they are, and you can access them for cleaning services is enough of a benefit.

Matthew Zipple 22:55

So that's interesting. Do you have evidence that, or do you believe that fish are individually recognizing shrimp? Or are they recognizing the station? Do they return to the same station repeatedly?

Eleanor Caves 23:09

So I don't have evidence that they are recognizing individual cleaning shrimp. I do think that they sometimes returned to the same station repeatedly. This is pretty anecdotal. But I'll see on my videos, some individual client fish are identifiable through you know, wear on their fins or a cut or a parasite or something. And sometimes you'll see a fish get cleaned, swim off and literally be back within a couple of minutes. So they probably just swam in a big circle and came right back. In some species for species for which we have information like Ancylomenes pedersoni which is this Caribbean species. The evidence suggests that clients are actually locating cleaner shrimp by having a spatial map in their memory of where cleaning stations are located. And they're really using those anemone hosts as the visual cue to hone in on the cleaning station from far away. They will pose at empty anemones. But, but it could be that they won't do that for very long, right? I would love to get out there and look at like, what happens if you take all the cleaner shrimp off of an active cleaning station? How long before clients stopped visiting? Or do they not stop visiting? Right? The cost of just hitting every anemone in your environment might not be very high? Or if you set up a new station or move one? How long does it take for them to figure that out? The situation is a little bit different in cleaner fish, which I don't study but there's a long history of studying especially cleaner wrasse, that's Labroides dimidiatus, and there is evidence there that clients recognize individual cleaners. And in fact, if they get poor service like they're cheated, that the cleaner takes a painful bite of healthy scales or tissue. Some clients those that have large territories and have the option to visit another station won't come back to the one where they were cheated for a while. That is a much more well studied cleaning system. And the dynamics of it turned out to be really complicated. It's... it's a cool system for thinking about exchange of goods and services in an animal system. And we just don't know anywhere close to that much about cleaner shrimp. Yet.

Matthew Zipple 25:20

So maybe that's a good transition point to ask, what do the next five years look like for you? What are your plans as you start up your own lab?

Eleanor Caves 25:26

I'm starting a faculty position. And, you know, there are so many questions I want to go after I have this folder on my desktop called ideas. And I just make a document for each idea. And it's kind of

overflowing. There's a bit of a trick here, right that I am a visual ecologist, I'm really interested in these signaling traits. So I have one branch of research that I'm really interested in, which is the diversity of signaling traits across cleaner shrimp species. So we see in cleaner shrimp, that they tend to have these white body parts that they wave around in the presence of, of clients. And we don't see the same number of white body parts in related non cleaning species. But these are shrimp that are distantly related. They're all over the globe. So could this be sort of convergent evolution on, as a form of signaling trait that all cleaner shrimp or most cleaner shrimp have come to? And if so, why white? Why would that be a particularly effective signal to clients that you're a mutualistic partner, and not just to clients, I mean, keeping in mind that the trick here is a single cleaner shrimp will serve as dozens of species of clients. So you have to have a signaling trait that is conspicuous to a lot of different visual systems. And then there's these ideas that I have that are steering away from vision and going more towards behavioral ecology. But I'm also really interested in the fact that no matter where you go around the globe, you go to these reef ecosystems and dozens of species of clients are a fish, all service clients, and they all seem to know where cleaning stations are located, and what to do when they get there. So how do they know? Could this be genetically controlled? Or more likely is it something that they learn by watching others? And if so, can they can they learn it from from heterospecific as well as conspecifics. And if you're going to do an experiment where you've already got, you know, naive clients interacting with cleaners, you might as well see if a naive client from the Red Sea could recognize a cleaner from the Caribbean, right? Are these white signaling traits that generalizable? So I've probably named a lot more than five years. But I also feel like, we just have so much to learn about the basic ecology of cleaner shrimp. And I would love to have a field site where I can go back repeatedly and get a better idea of the sort of long term dynamics of cleaning stations, how how long does the cleaning station exist? You know, do they actually ever die because they could just continually be resettled by new cleaners settling out of a plankton, what happens when they when they move? There's just so much we don't know. And that part is both daunting, and also really exciting. There's a lot of just like, basic behavioral ecology we can do that's going to be really cool, I think.

Matthew Zipple 28:24

Well, I'll definitely look forward to the long term demographic analysis of cleaning stations. We're going to take a quick break now. And when we come back, we'll talk about your scientific journey thus far, how you've dealt with previous challenges and what you're most excited about going forwards. But first, here's a two minute takeaway.

Chase Anselmo 28:47

I'm Chase and I research animal behavior at Louisiana State University. Down here in the bayou, we love to eat our crawfish. But when you sit down at the table, how do you know that it's time to eat? While your brain uses sensory information like sight of the red crawfish along with smell and taste of the spices to understand that you have food in front of you? Pair that sensory information with a grumbling belly and you're already digging into the food. We at the Marsuka Lab research how the brain combines sensory information from the external environment like taste, sound, and color with an animal's internal physiologies like hormones and state of hunger to allow animals a wide range of behaviors such as feeding parental care and reproduction. We use a little African cichlid fish that would fit in the palm of

your hand called Astatotilapia burtoni. Males of the species who become reproductively ready will change colors from a dull brown greenish color to bright yellow, orange and red, and they'll begin courting females which collectively sends visual signals that say, "Hey, I'm ready to reproduce." Recently, we've learned that when females cycle into reproductive readiness, they can see bright male colors much better, allowing them to more appropriately respond to male courtship. My research is look at this relation between vision and the reproductive cycle in females, we think that reproductive hormones can improve female visual sensitivity. And I'm investigating which hormones are important and how they operate within the eye. All kinds of animals such as fish, birds, reptiles, and mammals, including humans detect and process light in the eye extremely similarly, we also use nearly identical hormones to regulate our reproductive physiologies. And because of the similarities, my project will inform us beyond just the fish to teach us how these ancient mechanisms of hormonal sensory modulation have evolved, and how they can affect our behavior. So my final question to you is, do you see colors differently depending on your hormones? Probably, and I'm finding out how, thanks for listening,

Matthew Zipple 30:46

You can find Chase Anselmo on Twitter, @ChasingTheBrain

Matthew Zipple 30:54

All right, we're back. And now I'd love to talk a bit about your scientific journey. Correct me if I'm wrong. But prior to studying cleaning shrimp, you had previously studied vertebrate systems exclusively. So tell us a little bit about your scientific life before cleaner shrimp. And then tell us about why you made the switch to invertebrates, and cleaner shrimp specifically.

Eleanor Caves 31:17

I think I've known I wanted to be a biologist ever since I was a kid. And I think that animal behavior was like, the first thing I gravitated towards. And then I took this long circuitous route, where I thought, maybe I'll go to med school, maybe I'll be a sleep scientist. And then I came back to animal behavior. In college, I really had a mentor, Nina Karnovsky, while I was an undergraduate at Pomona College, who just really got me fired up about animal behavior and behavioral ecology. And to be honest, I think a big part of that was that she was willing to send students even as undergraduates to the field. So she sent me to the Farralon Islands, which are these tiny islands off the coast of San Francisco when I was a sophomore, to do a season of fieldwork, studying seabirds. And that was just like, so eye opening, it was an incredible experience. And she's really responsible for, you know, she took a huge chance on me, she had one person she could send out there to take all of her data for that field season. And she gave me that responsibility. And I hope I did well enough. But it certainly changed my path. So then, I thought about what I wanted to do after undergrad and I was, you know, I wanted to take a couple years off, you know, and not go straight to a PhD, but I didn't know what I wanted to do. So I applied for a fellowship to go to Cambridge and do a master's in the zoology department. And I was actually not accepted for that fellowship, I was the third place candidate. But then the first place guy got a more prestigious fellowship, and the second place guy actually never got into Cambridge, I think just through

an administrative fluke, like he was just never admitted. And so they gave me the fellowship. And I got to go to Cambridge and do a master's degree, where I was working with Claire Spottiswoode, who's a behavioral ecologist. But I was co advised by Martin Stevens, who's a visual ecologist. And that project was working on brood parasites, which are birds that don't make their own nest, they lay their eggs in the nest of a host, and sort of trick the host into accepting the egg and raising their young. And so we were looking at host eggs and parasite eggs, which have many parasites have evolved egg mimicry, so their eggs look almost exactly like post eggs. And so the host is really fooled into raising incubating the egg and raising the young. And we were trying to incorporate information about bird sensory ecology and vision into what we know about egg mimicry to look at how do these eggs actually appear to the host and the parasite. And I found that to be really fun, I love the sensory ecology part of it. But it was a bit of a black box to me, and that, like, a lot of data already exist on the sensory ecology of birds. So all I had to do was kind of download the supplemental data, get the right column out of your spreadsheet and plug that into a model of vision and outcomes, this answer about like "Oh, these things ought to be discriminable to a bird." Which was great, because a master's is only a year you don't have time to get too far into it. But so one of the things I wanted out of a PhD was the chance to generate those data myself right to figure out, here's an animal, we don't know anything about its visual capability, let's measure it ourselves. So that then we, we've made those values, we can plug into a visual model and look at what they might be able to see. And that was a goal of mine. But cleaner shrimp in particular... So I did my PhD with Sönke Johnsen and although i i had a sort of interest in these shrimp, because they were partly transparent, and we thought, well, they have great color patterns. We didn't know exactly what my PhD would be on. And in my first semester at Duke, Sönke was like, "Ah, well, you know, it'll take a while to get to your project. Why don't you just buy an animal on the internet and watch it and if that becomes your study organism, that's great. And if it doesn't like no harm done, at least you didn't waste a whole semester." So I bought a cleaner shrimp. Actually, actually bought a non cleaner, a closely related shrimp that was a non cleaner because they were out of the cleaner shrimp. But then later the cleaner shrimp arrived. And that's just how I got started, I thought it was the coolest animal I'd ever seen. So a little bit of serendipity there, you know, it was the third place to go to Cambridge. But I did, I ordered a shrimp on the internet. Here I am about to start my own lab studying cleaner shrimp.

Matthew Zipple 31:31

So as you mentioned, you've now spent substantial time in England during two different parts of your career, first as a Master's student at Cambridge. And now as a postdoc at Exeter, what stands out to you as the main differences in approaches or academic environment in England as compared to the US? And is there a component of the English approach that you'll try to bring to your lab?

Eleanor Caves 35:56

Oh, sure. Well, I think there are a lot of differences. And I think it's incredibly beneficial to get a look at how a whole other you know how science can be organized in a different way. The things I I want to try to remember when I get back to the US are really, that I think there's a slightly different attitude over here just at the level of the institution, right about, about what is the balance, you should strike between work and life outside of work. And to put it very bluntly, I just have a way better work life balance in the UK than I ever did in the US. I feel as though I mean, so my contract, I'm a postdoc, and I'm given 40

days of leave every year. Right? That's days that aren't weekend. So I basically get like two months off, and I'm encouraged to take it, I think that's the other thing is, like, people find it weird if I email them on a weekend, and I've really stopped emailing people after five o'clock, or even checking my own email after five, because people here won't respond anyway. And when people are on break, they're really on break. It's just different. So I think, you know, I can't go back to the US and force institutions to change. But I think I can encourage my own lab group to spend time, right, like, for their lives to remember that doing a PhD or a postdoc, or being a lab manager, these are, these are jobs. And sometimes you will put in more time for your job. But sometimes, you should just go on vacation and really be on vacation, because I will say over here, everyone seems just as productive despite the sort of fewer hours they put in, in the lab. So that's a feeling I really like. And I really like tea time that this is a very hard thing to bring back to the United States, because we just don't have the infrastructure for it right, like the tea room where there is a spigot of water at boiling temperature, and you can make tea at the drop of a hat and everyone's there at 1030. And you're actually like bullied if you aren't there at 1030. It's such a nice feeling.

Matthew Zipple 38:06

Well, so what you need to do is to put in an NSF infrastructure grant to support tea time

Eleanor Caves 38:11

For, for a kettle and a bunch of tea bags. Well, at Cambridge, we had a tea room and there was a woman who's like, whole job was just making his tea twice a day like this is this is a salaried position. But it was great, because I met more people at Cambridge, in a year, then then maybe I did it in like six years at Duke because if if giant name, Nick Davies or Tim Clutton-Brock, if they're at tea, you can talk to them, because they're at tea! And also, I will say, I think it ultimately saved me time, because the number of times I had run into a roadblock, and I just brought it up at tea, and someone would say, "Oh, I've solved that problem before I'll drop by after tea and show you how to do it." It was, it was really cool. So I will miss that.

Matthew Zipple 38:59

So you are obviously enormously successful as a grad student and postdoc. I know you've encountered some challenges, and we'll talk about those in a moment. But my sense is that you've also been quite happy during that time. So I'm wondering if you have some advice for current or prospective graduate students for achieving success and maintaining a personal well being at the same time

Eleanor Caves 39:23

I think that a lot of my happiness was because I was in a lab group where the leader of that group was really good at making us all feel valued and included. So I don't want to put all of the pressure for, for graduate student happiness on the PI but I do think that a huge amount of, of what needs to happen is, is at the level of lab policies, you know, everything from having some lab traditions so that you can feel like you're part of an in group you know, the first time it'll be weird because you don't know what's going

on like the lab, white elephant party or whatever. But the second time, you'll know what that is you're part of the group. I think that kind of stuff is really important. And so I think in general, for me, what helped with my happiness was making sure that that my time in the lab wasn't just about science, right? Like, we can often feel like those five or 10 minutes at the beginning of a meeting where we're just chit chatting with our colleagues that can feel like such a waste of time, sometimes you can be like, and I've been there myself, I've been like, I don't have time for this, like, I have got to do this other thing. But the truth is, like, I do have time for it. And I think everyone does better science and is happier, if they recognize that everyone else in the group is a human with a lived experience, who's gonna have good days and bad days and moods. And I'm not saying everyone in the group needs to be friends, that's never gonna happen, right? Like you can't bring group of people together and tell them all to be friends. But you can make sure that they understand who that person is, and that that person's opinion matters. And you can give everyone a chance to speak. And so I know that a lot of grad students might be saying, all these are things are great, but my PI just isn't like that. And I think in that case, finding another person to talk to about this stuff can be great. And often, when we're told to find an alternate mentor, we're told to find another faculty member or something, because they might know a lot about how to help you get your PhD done. But I would say a senior graduate student, or a postdoc, would be just as good. Find somebody that you can connect with, that is willing to listen, that will give you honest feedback. But be nice and supportive. That just goes such a long way.

Matthew Zipple 41:39

So you're an objectively very successful scholar. But something that I've heard you talk about before is the struggle that you've had with impostor syndrome, would you share some of that experience with us?

Eleanor Caves 41:52

Impostor syndrome is so real, I feel it all the time, at every level, and I think that is maybe something we should just all remember is like, we're all feeling it, no matter how successful you look externally. You just feel like, you know, even... even as a successful person, like I spent, like my entire job interview season, and I had objectively like a great job market experience. I spent the whole time feeling like, well, they're gonna discover I'm a phony on the next question. But I'm not a phony. And I know that. But you always worry about that stuff. And I think it's real. I think it never goes away. And you can choose whether you want to put this in the podcast or not. But the year that I did job interviews, I had such intense impostor syndrome, that I went out and got a tattoo. And it was personal to me, but it was my tattoo that reminds me, I belong in this field. And it's okay, I do have a place here. And, you know, that's just to say that the feeling was so crippling that I felt like I needed something permanent. That I could see, to remind me that I do have a place here. We all feel it. And it's a place to maybe start with some if you feel like you have nothing in common with someone else. You probably actually both have impostor syndrome.

Matthew Zipple 43:16

Yeah, I think that's, I think that's absolutely true. Okay, so we've now covered some of your great successes. One of the goals of the podcast is to give a well rounded view of our guests, and identify times of struggle as well. Would you be willing to share a time that you've really faced a challenge in your scientific career and how you overcame that?

Eleanor Caves 43:38

Yeah, sure, I would. And we should probably full disclosure that Matthew, you were there for this. So I don't know you can chime in if you want. Yeah. So in the last year of my PhD I got involved in I was a research assistant for Stephen Nowicki, who was not my PhD supervisor. But we were working together on a project about categorical color perception in zebra finches, and it was a large collaborative effort. So Patrick Green, Sönke Johnsen, Susan Peters, and you, Matthew, you were, we were all on this project together. And we got some really exciting results about categorical perception of color, which we felt might represent a paradigm shift in our understanding of signals and signal perception and evolution. And we submitted the thing to Nature, which was very exciting. It took a while, but then we got, you know, these four sets of reviews back and they were extremely comprehensive, and by and large, very constructive. And we went about working on those on those revisions. And I discovered in the process of doing those revisions that there was, we had done a sort of follow up experiment about how birds perceive shades of gray, to look at the influence of brightness on this categorical perception. And I discovered as we did those revisions that I had just made a calculation error. I had, I had just mixed something up in an excel spreadsheet, and we had basically done the grayscale experiment using the wrong shades of gray, the things that we had calculated just they weren't right.

Matthew Zipple 45:26

But no big deal, because that had only taken like a month.

Eleanor Caves 45:29

But no big deal, because that only took like, at least a month of testing these birds and, and all that. So. So I. Yeah, Matthew, you and I, we were sitting in my office, and we were faced with this just flat out mistake that I had made in a paper that was already under review at Nature. And I was a graduate student, this was still for me as a non graduate student, but at the time as a graduate student, I, I was completely floored, right, like, what do you do in this situation? Right, the papers already under review, it's potentially going to be a career maker for me and I have made a mistake. And so the results that we had presented maybe weren't at least some of the results that we had presented, right for this follow up experiment. They weren't right. And I think, I don't think I cried, but I got pretty close. Did I cry? I might have cried. Okay, so I think I probably I think I cried. And then we went and talked to Sönke. And then later to Steve. And I think part of your question, right was how did you figure out what to do? And the honest answer is that if I can hold up one example of how to be a good mentor, it is what Sönke and Steve did, both of them were just like. "You know what? It happens. We've all made mistakes, glad to see that you're human, like the rest of us. Let's just fix it, redo that part of the experiment. And we'll figure out from there, how to address this in the revisions." You know, there was no judgment, there

was no anger, there was only support and recognition that this is an absolutely human thing that happens. And the best thing you can do really, the only thing you can do as a as a responsible scientist is fix it and move forward. So we did we fixed it, we moved forward and the paper is in Nature, which is great. And I feel very fortunate about it. But that whole experience just yeah, the hidden... the hidden stories that you don't know about everything.

Matthew Zipple 47:43

Maybe we should say here that the conclusions were all right. We just didn't have any of the data to support that one claim we made about brightness the first time we did the experiment.

Eleanor Caves 47:52

Yeah, it's. Yeah, almost nothing changed, which is, which is always great. But what was nice was that I knew because of the behavior of my people more senior than me that even if things had changed, like it would have been okay. I know we did the right thing. And I hope that it means that Sönke and Steve can both… both trust all the work I do even more for it, you know?

Matthew Zipple 48:16

So let's close here. What is a question either broad or specific in your field, that you think that you or others are going to be able to answer soon, that we haven't been able to answer before.

Eleanor Caves 48:31

So many things, there can't be just one answer to this question. In the conversation I was having recently with Melissa Hughes. She mentioned this outstanding question that I think occurs right at my the intersection of my interest right, behavior and sensory biology. And she was pointing out like, as a field of signaling, we don't have a good understanding of whether there are relationships between signal form and information content, right. So for some signals, we like warning signals, toxicity and so on, we understand that there are like bright color patterns that are easier for potential predators to learn and an associate with distastefulness, etc. But like this general, like, given the information I want to send you what should my signal form be? It's such an interesting question. Are there certain types of signaling, signal trait or signal modalities that are better at conveying certain types of information than others? And I think that is just the most exciting question, and I don't know that I'm going to answer that. But I think that my particular contribution might be in the area of I think a lot about interspecific signaling. So signals between species I think a lot about signals between mutualistic partners. So what kind of signals can you send if the information you need to send needs to be conspicuous to a lot of different viewers and essentially, in which the costs of that information not being sent are potential... or could be death for you, right? If you don't inform a potential client, that's a predator that your cleaner maybe it would eat you. So the selection pressures ought to be pretty significant there. Yeah, maybe that's maybe that's my answer. Maybe we don't need to go further than that. Yeah.

Matthew Zipple 50:23

Excellent. That seems like a great place to leave it. Eleanor Caves. Thanks so much for joining us.

Eleanor Caves 50:29

Thanks for having me, Matthew. This was fun.

Matthew Zipple 50:33

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