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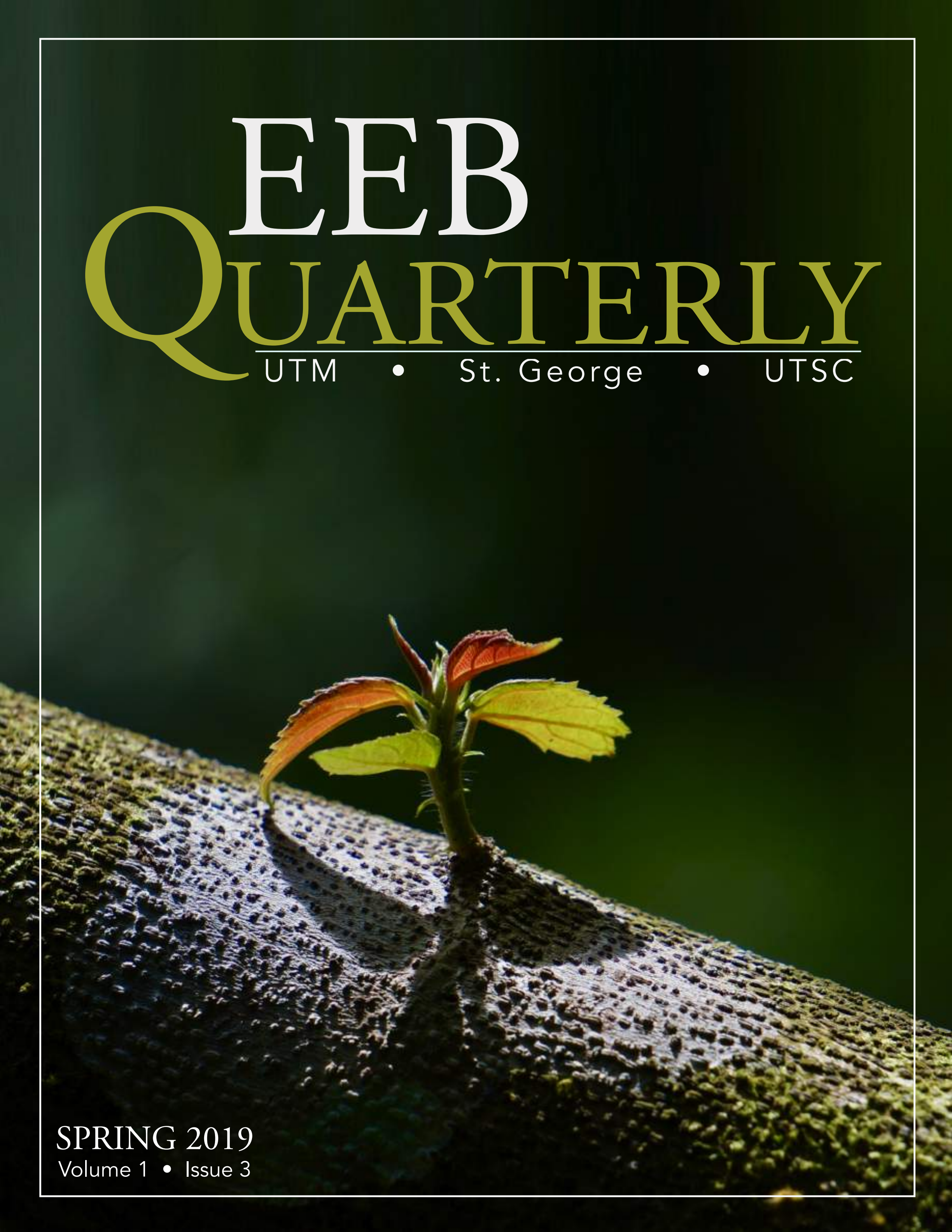

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MEET THE KEYNOTE

Sharon Strauss on Evolution in Communities, Jewelflowers, and Central Park Worms

Interview by Sean Anderson

YOUR 2019 ATWOOD LECTURER is Sharon Strauss, Professor in the Department of Evolution and Ecology at the University of California, Davis. Sharon's research on plant species interactions in the context of biogeographic history and niche evolution — or a lack thereof — has been influential in leading the integration of the evolutionary perspective into community ecology. She is a member of the American Academy of Arts and Sciences, and when it comes to plants, she's not afraid to pick favourites. This interview was edited for length and clarity.

I want to ask you a bit about science and the research you'll be discussing at Atwood, but I'd also like to kind of give people a sense of who you are, if you don't mind. So you're an evolutionary ecologist – what led you down this path? How did you get started out in research?

I always really liked animals and animal behaviour, so I went to undergrad thinking I wanted to do animal behaviour. I had a 'hall-bait' in my freshman year – and you know how freshman year relationships can be very powerful things in people's lives – and he just knew a lot of natural history. He knew plants, and herps, and he really kind of turned me on to thinking about other organisms.

In animal behaviour class I wrote a paper on the polygyny threshold in blackbirds. That's when a female, instead of being monogamous and having a relationship with one unmated male, chooses to be the second female in another male's terrirotry if that territory is richer in resources. And this really starts getting into the role of ecology in behaviour. My TA said "Oh, you should probably take ecology if you like this stuff", so I did. And actually I hated – well, hate is a strong word. I got A's in all my biology courses except ecology where I got a B.

But you didn't give up – you stayed interested in the role of ecology in evolution.

I did, ya

So how did that happen – did you go right to graduate school after undergrad?

That happened because I ended up being friends with a bunch of graduate students. I did an honors thesis. I worked for Maureen Stanton who was a graduate student at Harvard when I was undergrad, and I worked for her, collecting data for her over the summers – I ended up working on a couple of different summer projects actually – and I ended up becoming friends with a bunch of graduate students, so I never really thought much about it. It was sort of like "Oh, after you get your degree you go on to become a graduate student, after you're a graduate student you become a postdoc, and after a postdoc you get a job", and I just never really questioned it. I was happy doing what I was doing and I never really questioned whether I would move on to the next stage. It was just what you did.

Where does the love of animals come from? Did you grow up around nature?

I'm from New York City. Manhattan. Everybody says to me, "How did you become and ecologist if you are from Manhattan?". My Dad loved nature. He would take us out of the city, but only two or three times a year, if that. I don't know, I think maybe it's innate.

The great thing about growing up in New York City was that I had the Central Park Zoo, and I had the American Museum of Natural History, both of which I went to *constantly*. So I was really able to surround myself with animals all the time, and I loved them. I never had dolls; I only had animals. I mean I dug for worms in Central Park as a kid.

Did you find any?

Ya. I would take them from the wet mulch and put them out on the baseball diamond so I could watch them go into the ground better, which is not a great thing for a worm.

I don't suppose you've done that very recently?

Well, only in my garden, incidentally.

So now you're in grad school. Who were your biggest influences? Did you have any heroes — anyone that was big in the field that you thought were cool or that you looked up to?

I don't think I had any heroes going into graduate school. In graduate school I developed some heroes. People who inspired me were Jane Lubchenko, who taught me a class at Harvard, Lissy Coley whom I met at Barro Colarado Island, Doug Schemske whose work I just have always loved, and I would say Maureen Stanton too, who was a great mentor to me. Maybe not a hero but a mentor.

With the benefit of insight at this stage of your career, are there any early researchers that you see as important to your science in hindsight?

I have to say people on that first list are still pretty up there for me. I would probably add Rich Lensky to that list, Launica Gaber, Amy Angert, Joe Tobias and Alex Pigot – they do some amazing work. Those are people I would add to that list, some of whom I've never met, they're just people whose work I've read and thought "Dang that's really cool work". I would say [Dan] Rabosky always makes me think.

"On islands we see how flexible species' niches can be.. but also, we see that species are kind of hacks"

How did you come to learn about the mustards of the California Floristic Province, and what makes them such a fascinating system?

This is another bit of serendipity. My former colleague Sergei Nuzhdin came up and knocked on my office one day in the mid 2000's and said "Sharon don't be a dinosaur. Let's look at the genomics of speciation in something cool. In some plant. I need these criteria." There had been a big project here on serpentine ecology and adaptation from Kevin Rice and Maureen Stanton and Sharon Collins and Susan Harrison, and so I thought well maybe speciation in response to serpentine soil would be an interesting thing, 'cause you'd have serpentine and non-serpentine boundaries and that might be a good place to look at speciation islands. And in fact that famous *lyrata* paper (Turner et al. 2010) sort of was an outgrowth of this initial thing which was a failed project.

So I was out there looking for groups to work on with those criteria, and I found this group called *Streptanthis*. They're called jewelflowers – for a reason, they're really beautiful - and I just kind of fell in love. They were a really crappy system for what Sergei wanted because the serpentine and non-serpentine populations were never adjacent, so there was never a lot of gene flow. They were always isolated on weird outcrops, so Sergei switched to other systems that were more suitable. But I got stuck on the jewelflowers. They were just beautiful and cool and I just started working on them. You know you start reading about them and thinking about them – they have so many different cool weird little adaptations we have just begun to plumb.

You focus a lot on evolution in ecology. One of the most profound shifts over the last few decades is the understanding that adaptation can happen quickly, on ecological timescales, even in species you might not expect it to (e.g. vertebrate animals with small populations). How does this change our understanding of communities and coexistence? Does it change the questions we should be asking?

Well, I definitely believe that evolution in communities is ongoing and contributes to the functioning of communities. However, I do feel that in many of the cases where we see dramatic results, it's been in simplified systems – so we see it in islands where there's just not that many other species, or you damn a lake and all of a sudden you totally change it and you get rapid adaptation, you see it in urban settings. But when we look in complex communities, there are often so many different species and aspects that are exerting conflicting selection on a species that trait evolution may be occurring from year to year, but it's very bounded. It's harder to see how [evolution] influences the functioning, although I think that it probably does – I think if we could stop species from evolving we'd probably see what their function was,, but that's hard to do in a realistic way.

It's in the simplified systems where we can really see that ecologically-relevant evolution. The problem is that it's harder to see in complex communities, and evolution is never directional in a sustained way in complex communities – it's constantly fluctuating.

Can you summarize the importance of a phylogenetic perspective in community ecology?

Yep. So, there are different levels of phylogenetic approaches. For starters, which species are actually present to form a community is the result of the evolutionary history of clades. People tend to forget that and say "Well, evolutionary history doesn't tell us anything about this community"; well, actually, what species are *there* to begin with is all about the evolutionary history and biogeographic origin of clades.

There's been some really cool work done by Ellen Damschen and Susan Harrison (Copeland et al. 2016), which shows that as we're having these dryer and hotter trends in California, if you ask how traits are changing across a community, you find that heat-and-drought-adapted traits are increasing. Well, ok, that makes sense. But I think the coolest part of the study is that when you look at which *clades* are increasing or decreasing in communities, you find that the desert origin clades are increasing. The more mesic northern clades are decreasing. So all of a sudden this becomes not just "a more succulent leaf or smaller leaf is favored", but actually you're looking at the evolutionary history of clades to see which species have these kinds of traits more often, and how the community is changing right now in response. So I would say it's important just to understand the biogeographic origins of the groups and communities that you're studying. That's where a knowledge of the evolutionary history can really contribute to your understanding of community patterns.

Evolutionary history is also interesting because of the constraints on what species can and can't do. That's especially important in island communities. You have species that arrive on an isolated island and then radiate to fill empty niches. This tells us that at least some species can evolve to fill a lot of different ecological functions. But then – they're not that great at it! And this is because of their evolutionary constraints. I mean if you introduced squirrels to Australia, I'm sure you could collapse the parrot radiation in Australia. The fact that there are no squirrels there is, you know, allowing that. So on islands we can really see just how flexible species' niches can be, but then, also, we see that species are kind of hacks in many ways, and that there are species out there that could do the job better. If you homogenized immigration and dispersal around the globe, you would start losing a lot of diversity just based on the fact that dispersal limitation across major features has resulted in ecological niche spaces that are inefficiently occupied by species due to the constraints of their evolutionary history.

And then some of these phylogenetic approaches of Rabosky, for example, can tell us whether there is species saturation in communities and test for certain ecological patterns in the latitudinal gradient. These are things where the phylogenetic history adds a lot to our understanding.

To summarize: I think phylogenies can be important. I certainly believe in my heart – which is not the way a scientist should believe, so I believe from my observations – that close relatives share a lot of ecology, and that at some level those shared aspects are going to influence community functioning.

You incorporate macroevolutionary history and speciation in the understanding of communities and coexistence. Regarding speciation and the coexistence of close relatives, much of the classic thinking was based on patterns observed in birds (e.g. thanks to Mayr, MacArthur, and later Diamond and especially the Grants), which tended to emphasize things like limiting similarity and character displacement. Has a focus on plants provided you a different interpretation of the processes that are most important to consider when understanding coexistence following speciation?

Yes. I wrote a paper looking at the geography and speciation of plants in the Caliifornia Floristic Province and we found, among 22 clades for which had complete phylogenies, that sister species were either parapatric or sympatric in most cases, which is not what you see in birds. Dena Grossenbacher has written similar papers, and one just came out – Skeels and Cardillo (2019) - that support these ideas. They use a simulation model that I haven't gone through all the details on, so I don't know how good it is, but I believe the results so I guess I believe the model (laughs). Basically they looked at six clades of plants and clades of mammals and birds, reptiles, amphibians, fish, and insects, and their models say that in almost every clade of plants, there's much more support for sympatric or parapatric speciation than any other model... But this gets back to your question: yes, when it comes to speciation and coexistence, the fact is plants do it differently and you end up with possibly different types of challenges.

Which brings me to a point … well actually I don't want to scoop myself so never mind. There's a big focus on competition but I don't think that's the whole story in why you don't see coexistence in close relatives.

What is the most rewarding part of your job?

The most rewarding part of my job by a long shot is mentoring graduate students. I just love to do that.

Is it a skill you pick up, or did you always feel comfortable doing it?

I did feel comfortable doing it. Every graduate student is different and has different needs, so some students are easier than others. I've been blessed being in a place like Davis. I really get very sharp, motivated students – it's not like every student has finished, and I definitely get students that struggle, but you just end up being able to work constructively and think creatively with students.

I always let my students do their own projects, so very few of them have actually worked in systems that I'm working in. It's a very old fashioned model, but it's really fun for me because I get to learn a lot about a lot of different systems and think about them and work creatively with them, applying things I know about other systems.

How do you find novelty? Where do you look for new questions or systems to investigate?

That's sort of like asking "How do you find creativity?" I think reading a lot is great. I don't read as much as I should and I read a lot less now, and I feel like I have fewer good ideas now because I'm just not reading as much as I should. It's hard to keep up with this huge literature – that's part of it. It's just so daunting that at some point you just kind of shut down. Even if you're interested in a narrow topic. You used to be able to be a broadly read person and now it's hard to even keep up with one field.

But a lot of times I just look in nature for novelty and ideas. You're out there and you're looking at this plant and all a sudden you see this thing that looks kind of interesting. And then you just start playing around with it and you think "Oh, that's actually more interesting than I thought". And then that question leads to another question. And that's kind of how I've done my science. Just

Sharon with the 'desert candle', *Caulanthus inflatus*

kind of immersing myself with the organism.

I also religiously go to seminars. I go to meetings and I sit in talks from eight-till-five and I do relatively little schmoozing. I pick and choose the things I'm interested in and get exposed to new ideas that way. It's sort of like a crash course in the literature. I don't always necessarily go to big named talks, I go to talks that are about things that I'm thinking about, but sometimes it's a really diverse group of topics.

You've put considerable focus on *applying* evolutionary knowledge to real-world problems of environmental change, and I think sometimes it's difficult to see how this applies. How can we most effectively deploy our understanding of evolution, in light of ecology, to conserve biodiversity?

Well I'm married to a conservation scientist — he doesn't even call himself a biologist anymore — so the first thing I have to say is the key things for conservation are clearly habitat protection and social structures, policy, and all of that. That's all way more important than anything else we do.

But, you know, if you want to talk about evolutionary approaches, I've always wanted to do the experiment of just putting together a huge mishsmash of population sources. Like you have some threatened species, just get as many populations together as you can, throw them all in one spot, let natural selection work on all that variation — you'll have maladaptation, you'll have a dip I'm sure, and you're going to come out probably with some combination that's a little bit better. And in the process you're going to screw up the whole sanctity of the unique population history, and it would suck in that regard, but when you're in a triage situation for many species there's no choice that's a good choice.

Overall, I think contemporary evolution will help us a little, but it's relatively small in relation to these other things that are really impacting species. But that doesn't mean we should ignore it.

Are you familiar with Desert Island Discs, the radio show?

No.

It's been on the BBC for about 75 years, and the conceit is that you're about to cast on a desert island, but you get to take some important things with you. So my question is: you're cast on a desert island and you get to take one jewelflower with you. Which one is coming to your island?

Easy. *Caulanthus inflatus*

Why is that easy?

It's called desert candle. You can google it and you'll see.

You've got it. The next thing is that you can bring a song, a book, and a luxury. Any idea what you'd choose?

I was trying to think if there is a book I could read over and over and over again. I have a really ultra-nerdy answer, and an only very-nerdy answer. One is the complete set of Shakespeare plays, because there's a lot in Shakespeare and I actually was almost an English major and I really do like Shakespeare. The other is the Jepson Manual 2 [The Jepsom Manual of Vascular Plants of California], which could let me look at species traits forever and ponder patterns.

What about a song?

That one, honestly, I can't think of any song I could listen to over and over again without going crazy. I'll have to take a rain cheque on the song.

Fair enough. Any idea on the luxury?

I was thinking a Japanese soaking tub would be nice. I might starve to death but at least I'll be relaxed.

We have a 'disasters workshop' at our school, where faculty and postdocs tell stories of science-gone-wrong (e.g failed experiments, field work snafus, etc.). The idea is to give students a sense of resilience and hope (and perverse delight) and to give faculty a chance to laugh-away a crappy incident. Do you have a science disaster story that you're willing to share with us?

Sure. I've had lots of disasters. Probably my most disastrous project was when I set up an experiment along a transect from coast-to-inland looking at a colour pattern polymorphism in wild radish populations. At the coastal site I had the Bodega Marine Reserve that I could use, and further inland I had sites along the roadside.

When you're working on the roadsides you have to talk to the highway company and make sure they don't mow them, and you have to get all these permissions and let them know you're doing this. And it turned out every roadside population was destroyed by something. I'd gotten permission from the highways, but then the PG&E (Pacific Gas and Electric) sprayed herbicide around the poll. Cows got out and trampled one area. Then my most horrifying one was out in Dixon where I had a population that was doing fine, and then I realized that in the field next to it they were growing daikon for seed, which is the same species. So the population was contaminated by all this gene flow from radish that was being cultivated for seed. And at that point I was like I'm only working on reserves. I will never not work on reserves. It was actually a big lesson for me.

What are the biggest changes you've seen in the field over your career?

Big data would be one of them.

A cultural change has been the move to mult-authored works. When I was starting out, it was horrible to have your P.I. be a co-author on your paper, because it didn't show your independence and your ability to think by yourself. So there was a huge emphasis on single authored work. And now you get a CV with a lot of single author work and you think this person doesn't play well with others. It's a wholly different thing, and it's a little hard to understand what people's roles are in many of these papers. But it is a real culture change in how we do science, and I think that's interesting.

What excites you right now about the field What do you think is interesting and compelling going forward?

I'm really excited about what large-scale data can bring to our understanding of ecology. That includes phylogenetic data, but also these big vegetation scans that look at productivity and identify which species are there by light reflectance, or their density by reflectance.

So much of the focus in ecology has been on hypothesis testing, which has required small-scale experiments, and I feel like we're getting to the point now where we can actually do hypothesis testing using large-scale descriptive data in ways that are going to be meaningful and interesting and that are going to give us perhaps deeper insights because of the limitations of small-scale experimentation. And that's not to say that I don't do small-scale experimentation – I do. But I think this whole area of large-scale data is so exciting and that it can potentially give us a much deeper, long-term, large-scale understanding. I think of it as Big Ecology. That is really going to help us, I think, understand more in the future.

Special thanks to Sharon, Alison, and Chelsea for sharing their time with us.
-The Editors

Leveret in Hand.
Quite literally the world's cutest organism, a baby snowshoe hare. Photo by Laura McCaw