PLANT PEOPLE Season Three Episode Nine "Cycads with Dr. Dennis Stevenson" Transcript

Jennifer Bernstein Narration: At least as far back as 200 million years ago, cycads grew in abundance. And at the peak of their distribution and diversity, they lived alongside the dinosaurs. These so-called living fossils were a fixture of tropical, prehistoric landscapes and have changed little since then. Yet today they face their greatest threats in poaching, habitat destruction, and climate change.

I'm Jennifer Bernstein, CEO and the William C. Steere Senior President at the New York Botanical Garden, and this is Plant People.

Today I'm joined by Dr. Dennis Stevenson. Previously our Vice President for Botanical Science here at NYBG, and currently the Senior Curator Emeritus Editor at Botanical Review. He is one of the world's top cycad experts, and together we're exploring the storied past and challenging future of these ancient and unique plants.

Jennifer Bernstein: Hi Dennis. Welcome to Plant People.

Dennis Stevenson: Well, I'm glad to be here. Thanks for having me.

Jennifer: Well, I'm so glad to talk to you today. It's always fun to speak with you and we're going to have a great conversation about cycads and you are the perfect person to have that conversation with. So, for listeners who may not be familiar, what exactly are cycads and how do they differ from more common plants like ferns or palms?

Dennis: Well, they're very ancient lineage as we pointed out, but it's their growth habit. They tend to be single stem plants that we don't think of as very branched, and they really look like a cactus with palm leaves.

Jennifer: Yeah. That's a good description. So, what drew you to focus your research on cycads?

Dennis: Well, that's a very interesting story actually. My academic grandfather had published on the structure of the growing points of cycads in several papers, and they were always of interest to me. But, sometimes things in your career are serendipitous. And after I finished my Ph.D., I had a postdoc at Harvard University, but I was stationed at Fairchild Tropical Garden in Miami and they

have the best cycad collection in the world. And I'm going, “Hmm, this is perfect.” So, I think that's what really started it for me.

Jennifer: I can see how being at Fairchild, you would be inspired because they have some incredible plants there, and I love that phrase “academic grandfather.” Can you explain what that means for our listeners?

Dennis: Yes. My major professor for my Ph.D., it was his professor and he was on my Ph.D. committee, my academic grandfather, except he passed and they were the authors of the primary plant morphology textbook through three or four editions.

Jennifer: I've heard other colleagues of ours talk about their forebearers in science in exactly that same way. And I think it's nice because it speaks to the continuity of science and the fact that nothing is ever really fully resolved in one person's career. We're always continuing to broaden our understanding. So, it's a nice turn of phrase. So, you found them interesting. You found yourself at a place where they were in abundance. What about them has kept you focused for so long?

Dennis: I've gone through various phases in studying them, and the first phase was taking up where my academic grandfather left off in the developmental anatomy or structure of that shoot system. It so happened that simultaneously, a man that I knew as an undergraduate had given a talk at the Ohio Academy of Science meeting, and he was retiring to Fairchild and he was interested in the reproduction of these plants and their reproductive cycle is just amazing. They’re the few seed plants, actually the only ones I guess extent, that have motile male gametes, and they have these sperm cells that are so big, you can see them on the slide with a naked eye. And so then the idea was, “Well, we have all these living plants there. We could look at them experimentally to see how this system really works.” So, once I did the anatomy stuff, I then moved into the reproductive side. And the pollination biology, because nobody knew how they got pollinated yet. They have male plants versus female plants. How does the pollen get over there and how does the system work? So, because there's a native one in Florida and in the wild areas at the Montgomery Botanical Center, I was able to work out the reproductive cycle of them in some detail.

Jennifer: Hmm.

Dennis: Then I went, “Well, you know, they got these really weird compounds. And one of them is called BMAA and it's a neurotoxin. It's a non-protein amino

acid to be specific. But the really cool part was we found weevil pollination in these plants and that the weevils were consuming the plant. So, we went, “Whoa, wait a minute. These guys should be dead.” But they weren't dead, they were living. So, we tried to figure out how did they deal with this BMAA, and it ends up that they actually sequester it in their cocoon cases and make poisonous cocoon cases against their predators.

Jennifer: So, the pollinators, the weevils, were also eating them?

Dennis: Yep. They eat them and they sequester this BMAA, they secrete out into their cocoon cases. So, it doesn't stop them from growing. Any other organism? Well, we would just die.

Jennifer: Right.

Dennis: There’s something called cattle staggers in Australia where the livestock will eat cycad leaves and it's a neurotoxin, in fact, Oliver Sacks wrote a whole book on them, The Island of the Colorblind.

Jennifer: So, they sequester it so that the weevils can still pollinate and do what they're doing without dying, but so that they can still procreate.

Dennis: So as the weevils go through their life cycle by copulating on the female cones and then ovipositing on the male cones. So, they go through their life cycle inside these plants.

Jennifer: Mm. It's amazing all of the strategies that plants have developed. So, let's talk a little bit about this description that you often hear about cycads as living fossils. What does that mean and what do we know about their ancient history alongside dinosaurs?

Dennis: The older I get, the more I identify with living fossils, I must say. It's because of the early fossil record in the early Permian. They remain little changed, but yet they survive the vicissitudes of time. So, you've got to say, okay, what's the secret? What's going on in this group of organisms that allow that? Well, there are certain things like the neurotoxins have developed would be a good one that keeps your predators from munching on you. But, the timeframe is that because from what we know in the fossil record, and it's pretty good, and there's some details in there, it allows us to have a plant that resembles a fossil, but it's still alive. So, we can look at its life cycle and how it's functioning in a modern context, on how they might compare to the conifers, ginkgo and then of course the flowering plants. So, there are lessons to be

learned by looking at different organisms. Just as looking at ferns might help me understand cycads.

Jennifer: Interesting. So, they have this long persistence and that allows us to understand what strategies they're using and from that, what do we learn about biodiversity in general? Have we taken that knowledge and applied it in some particular ways?

Dennis: Yes, in a way, because what we've learned from studying the extants, we do know the foibles they have. So, we know that they were widespread and covered everywhere, and now of course they're very restricted. So, what are their foibles? Well, one of their foibles was in their reproductive system because it takes too long to get from one generation to the next. I mean, the fastest you could do to raise a plant from seed to making a cone, and that's under optimum greenhouse conditions, is five years. Many of these plants at Fairchild had been there 50 years before they made a cone. So, not only do you have a long life cycle, which means you can't have a lot of genetic turnover in terms of mutations, but that whole process with the weevils takes almost two years. So, part of the lesson is gigantism probably doesn't do you any good.

Big unbranched plant, giant sperm, huge seeds with all kinds of stored stuff in them. Often for naught.

Jennifer: Yeah, but they've done okay.

Dennis: They're doing okay. And if we leave them alone, they'll continue to do okay.

Jennifer: The pods are so fun to see. They're often there in the Conservatory. And I always point them out when I'm there with a visitor because they're amazing. And now I have more information to share about why they're so amazing.

Dennis: You know, the tree stump thing that's in that house?

Jennifer: Mm-hmm.

Dennis: Well, that plant, that *Cycas* that’s next to it, is one of an original plant to the Conservatory from 1905.

Jennifer: Oh, wow. Wow. That's amazing.

Dennis: That's amazing. They're long-lived.

Jennifer: Yeah. Yeah.

So, you mentioned a little bit about the range and how it's changed over time. Where in the world today do cycads grow naturally? And why are those environments particularly suitable?

Dennis: One country that does pretty well with them is Australia, and I think it's partially because the Australians haven't destroyed their landscapes, in a sense. So, I think these plants just survive there. No known herbivores. And then parts of Africa, tropical Africa into Central Africa where we still have undeveloped mountainous areas and the plants seem to do well there. And really it's the same thing in the New World. The odd man out a little bit is our one species in North America that's not a fossil is Zamia pumila in Florida. And that seems to do well, and I think it does well because they're ones where if you damage them and they often can make a second branch or two branches, and so they seem to be able to survive that kind of disturbance that goes on. They're underground. That's another secret some of them have used so fires and desert situations don't damage them.

Jennifer: So, you said it's not a fossil. Does that mean that this is a later species? It hasn't been around as long.

Dennis: Yeah. They look pretty much the same. But for some reason we would never put a fossil in a modern genus in the classification. I don't know why, but that's just what we do.

Jennifer: Okay. So, this is a taxonomical artifact.

Dennis: Yeah. But they look just like them. You'll get a kick out of this. I even reconstructed a fossil cone once because when you go to the lab and you see those big jars with the pickle things. Well, the liquid all dried out and it dried out and it looked identical to a fossil.

Jennifer: Okay.

Dennis: So, I sent a picture to a paleo botanist and said, “Look what I found.”

Jennifer: Did it work?

Dennis: It worked, it did.

Jennifer: Okay. So, many people are surprised to learn that cycads do still play very important ecological roles. So, what benefits do they bring to their ecosystem?

Dennis: Okay. Well, they have these roots called coralloid roots. And what it is they're ageotrophic, so they grow up towards the surface of the soil and so they don't, instead of growing down, they grow up.

Jennifer: Okay.

Dennis: And they form little masses around the base of the plant. And they have in them a blue green alga or cyanobacterium as they're called. That's a nitrogen fixer.

Jennifer: Huh. They come with their own fertilizer.

Dennis: And they also can take a soil and add nitrogen to the area. It's really quite interesting because the other important nitrogen fixers that we know of are the bean family. But they use a different bacterium in a different way. The nitrogen thing was a big thing. Gloria Coruzzi and I had a couple grants working on that.

Jennifer: Does that mean that they have a role to play in restoration efforts?

Dennis: Partially, but also we want to know how that system works so we can utilize that to our system. So, if we can dissect the pathways it uses, et cetera,

Jennifer: You can replicate it in other ways…

Dennis: Yeah, because there is a nitrogen pathway in the plant and there's actually a nitrogen pathway in the blue-green algae. When they're living in the cycad, they use a third route.

Jennifer: Hmm.

Dennis: So, this obviously tells us something about making a situation where we could utilize these in crop plants.

Jennifer: Hmm.

Dennis: Not to expect the normal situation, but to do it in such a way to utilize the known third route.

Jennifer: So, a new route for nitrogen fixing that could be applied in crop situations…

Dennis: Exactly.

Jennifer: That's very interesting. Conservationists warn that cycads are now among the most endangered plant groups on earth. What are the main threats that they're facing today?

Dennis: One of them is habitat destruction. The other one is the illegal trade. I was very involved in that with the IUCN and developing an action plan and actually getting legislations passed to get certain things down listed. And I'll explain that. So, we tried to convince a community, you don't need a big plant, you can watch one grow.

Jennifer: Mhm.

Dennis: So, we really pushed the downloading seeds. And that's because one person might have a pollen plant in Iowa and someone in England's got the ovulate plant. What are they going to do? So, if they could send their pollen over and get seeds, they can then disperse those cultivated seeds and not take from the wild. So…

Jennifer: So, is that what you did through the IUCN?

Dennis: We did. Yeah, that was one of the things that we did to try to stop, because there's certain cultures that view a plant in your collection only of value if it's wild collected. So, we had to get past that. At the same time, cactus people know this same problem.

Jennifer: Yeah. Cactus poaching has been a problem for a long time and ramped up actually recently during the pandemic. The demand…

Dennis: Yeah. But the big push we did, also, I should mention this one, because it's so successful, particularly in Mexico working with Indigenous people. Don't go in that forest if some guy gives you $5 for a $200 plant for him. Go in the forest, harvest a seed, start a nursery. So, we actually got a grant to subsidize us starting in nurseries…they grow the seedlings up and they sell the plants. And there's a continuous renewable income then for the Indigenous people.

Jennifer: That's a great example of creating a bioeconomy and doing it to a conservation end. So, that's terrific. The International Union for the Conservation of Nature…I think it's worth just saying a word about what that organization does. We've talked about it on this podcast before, but this is an organization of conservation practitioners and scientists who identify threatened species, and they will put them on various lists of concern. The Red List is a very notable one, and it sounds like your work with them was about creating. Frameworks for disrupting the poaching that was happening. I'm interested to know, who's doing the poaching? Is it like a mass market gardener? Who is it…the end user?

Dennis: It's the same mentality as the cacti or orchid people. People want to expand their cycad collection and they'll do anything to go get them. Often someone would just fund a trip because they wanted to go somewhere and they could sneak some plants back. But I would go back to your IUCN comment because I founded the Cycad Specialist Group. And the first thing we did is make a world list of all the cycads. It's available online now. It's been through several reiterations, but we've listed then the threat to each species and given its distribution. And I think the good thing is some things have been down listed…

Jennifer: Meaning that they've gone from the Red List…

Dennis: They've gone from appendix one, put on appendix two.

Jennifer: Yeah. That's good. That means that the efforts are working.

Dennis: Exactly.

Jennifer: It's a great organization and many of our scientists here at NYBG participate in the process that they undertake. And it's an important input to conservation frameworks and to conservation practices all over the world. I mean, we're a collections-based institution. I understand the impulse to collect. And these things are things of beauty. So, I can understand the desire to have them, but not at the risk of the plant going extinct. That's not okay.

Dennis: Well, I think cutting one leaf off to make a herbarium specimen's probably fine.

Jennifer: Yeah. Okay. So, there's a range.

Dennis: Yeah, as opposed to digging it up, yeah.

Jennifer: Well, it sounds like there are better alternatives now for people to get these plants if they want them. And watching them grow, I imagine can be very satisfying for folks.

You said that there are species that are being down listed. Are there places where that's been particularly successful, where wild populations are, regenerating or thriving in a way that at one point seemed unlikely?

Dennis: There's a real focus in Mexico, for example. Another area where there's a focus is in South Africa, Australia, and China. China's gotten really good about that kind of thing now.

Jennifer: Yeah. It's interesting to think about places that are at different stages of development now in the context of the current science and the biodiversity crisis. So, much of the development that was happening in the Industrial Revolution, was taking place without the benefit of our current understanding about the way that these systems can and cannot regenerate and what happens when we lose species. But today we have a lot more information. So, maybe countries are approaching it differently.

Dennis: And I think getting the amateur community to raise plants and seedlings and stuff has also helped.

Jennifer: Yeah, well this is a way in which the exchange of information as between the scientific community and the vocational hobbyist has improved a lot with the internet. People who are interested in plants and who want to collect them, but don't want to do it in a way that's irresponsible, have ready access to a lot more information than they once did. So, maybe that's helping.

Dennis: Yeah, I believe that's true.

Jennifer: It sort of tracks with the growing interest in native plants. It's the other side of the coin, if you're interested in plants in general, then you're thinking about systems. You're thinking about how to support your local biodiversity and maybe you also are interested in rare plants, but you don't want to be irresponsible about it. So, I think it's a good thing for there to be more global awareness about what are the most pressing conservation issues related to cycads right now…It sounds like there's been a lot of progress on the poaching question. What about habitat destruction? That's harder to deal with, isn’t it?

Dennis: Yeah, it is. It definitely is, I mean, there are various kinds of examples. If you're in the Amazon area and you flood an area, these guys are not aquatics.

Jennifer: Right.

Dennis: They're gone.

Jennifer: Yeah.

Dennis: And once you wipe them out in a place like that, to get it back, it's going to be very, very difficult. So, it's various kinds of habitat destructions, because cycads aren't all desert plants. A lot of them are rainforest plants in South America. There's one epithetic one we have in the conservatory that's actually only found in the tops of trees in the mountains of Panama. That one is really, really threatened. As they keep cutting down for timber and various other usages, its habitat's going to be gone.

Jennifer: You mentioned this idea of you don't know what you're losing when you lose a species because you don't know what you haven't yet understood. Are there potential uses, for example, human uses of these plants that you think we don't fully understand yet, but could be lost? Are there medical applications? I would think with a neurotoxin, there could be.

Dennis: There's been some pursuit of it, but it stopped. But the notion of understanding neurodegeneration, like Oliver [Sacks] wrote about with this BMAA compound as an experimental compound. And we actually, Gloria Coruzzi and I, actually were using it in that little plant that botanists can grow by the thousands Arabidopsis or the Thale cress, the experimental plant using BMAA on it. And we got some interesting results of what it could do, we passed it off to some neuro people, but they never really picked it up.

Jennifer: Yeah. And so that's a good example, Dennis, because maybe in the moment in time with the available funding, that wasn't something that someone picked up. But that doesn't mean that the inquiry is done, but if the plants are extinct, there's nowhere to go with it.

Dennis: Nowhere to go. Good point.

Jennifer: So, an important reason to think about how we protect these plants. So, if we have listeners who are interested in cycads, where would you point them to learn more and where would you point them to help protect these plants?

Dennis: There's a website called the Cycad Pages, which I think is extinct now that Ken Hill died, but it's still available.

But there's a new one called the World List of Cycads. There's pictures of every species, where they are, ancillary information. Photos of herbarium specimens and field photos, and we're constantly updating them. So, there'll be a section on neurotoxicity on those pages, there'll be a section on chromosome numbers. There'll be a section on various topics that deal with them.

Jennifer: How many plants do you have at your home, Dennis?

Dennis: Hardly any.

Jennifer: Yeah. This is a thing about botanists that is surprising. They don't cultivate plants indoors, really. It's not their thing.

Dennis: Well, Jan goes nuts in our garden…

Jennifer: Okay. Okay, good.

Dennis: But yeah, all…indoor plants…no, she doesn't want them either, you know.

Jennifer: Yeah. Well, Dennis, it's really fun to talk to you. Always. Thanks for coming to talk to us about cycads here on Plant People.

Dennis: Thank you very much.

Jennifer: With hundreds of millions of years of cycad success behind us, it's all the more important that these living fossils survive this difficult time in their history for the benefit of the planet and for future generations. If you'd like to learn more about what you've heard in this episode, check out our show notes at NYBG.org.

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