**POLLINATORS.INFO PODCAST EPISODE 4: INTERVIEW WITH DR. NATHAN HOLLAND**

Quick Glossary of science terms that aren't explained in this podcast:

- Population dynamics: these include reproductive rate, death rate, immigration and emigration rate.
- Positive feedback: this happens when a result causes an increase in more of the same; in this case, an example would be that one female moth laying more eggs on cacti increased the number of female moths that laid more eggs than their mothers, and so on.
- Mutualistic species: these are species that benefit each other
- Obligate mutualism: these are species that MUST interact with each other to survive
- 10mm= 0.4 inches
- 4- 5 meters= 13- 15 feet

Athena (ARA): Hi there! I'm Athena, the author of pollinators.info, and you're listening to podcast episode 4. This is an interview with Dr. Nathan Holland, who studies senita cactus and senita moth pollinator interactions.

Well, first of all, thank you so much for your time today and for joining me to do a podcast!

Dr. Holland (NH): No worries.

ARA: I'm excited that I could find someone to talk about moths! A lot of people don't realize that moths are important pollinators too.

NH: That is very true. They're often under-appreciated. They're out at night, and people don't often go out at night as often.

ARA: Ok, so how would you describe your job, or what is your position, so people will know what it is that you do?

NH: Ok, so I am a research professor at a university, and my job entails teaching, as well as research that future generations will learn from.

ARA: And where do you teach?

NH: I am, right now, with the University of Houston.

ARA: Ok. How would you briefly kind of sum-up your research with the senita moth and the cactus?

NH: Well, I initially got interested in this system as a model system in which to investigate theory about positive interactions between species that have positive effects on both of the species.

And, so, this is a fairly specialized system, and a one-to-one relationship between the moth species and the cactus species, and that made it fairly tractable for me to develop theory and test it in nature to understand two major questions:

1. What determines the **population dynamics** of the interacting species?
2. And, why doesn't this **positive feedback** lead to **mutualistic species**, such as moths and cacti, just growing indefinitely?

ARA: Now, can you explain what you mean by a one-to-one relationship with the moth and the cactus?

NH: By one-to-one relationship, I mean that the cactus has a pollinator, and that pollinator is the one and only pollinator. And, in turn, the moth has one plant that it pollinates, and it interacts with that one, and only one, plant.

ARA: Oh, ok. So, this would be an **obligate mutualism** between the two?

NH: Right, so it's very much so an obligate interaction which, as we're learning, that such systems are less common than we previously thought. So, in nature, most plants are pollinated by many different species, and many pollinators interact with many different plants. And, it's less common to have just one pollinator that interacts with one plant, and one plant that depends on just one pollinator. That leads to some ecological issues that can be problematic if one or the other disappeared.

ARA: Right, so what, specifically, are you looking at with this system?

NH: One of the issues I'm trying to address and understand, which we've studied in ecology for many, many decades with other types of species interactions, is: how does the density of the moth, as a mutualist, influence the reproduction and consequently the density of the cactus? So, how is it that abundance influences, shapes, and molds the interactions between the moth and the cactus? Because you can imagine that we generally think that more is better, you know, "More cake for me after dinner!" So, often times we think about that in terms of mutualism, but it may actually be the case where more is not better.

ARA: Ok. So, in this case, what exactly would that mean? More moths are not necessarily better for the plant?

NH: Right, so as it turns out, the senita moth is kind of like yucca moths; it's doing the plant a really great service by pollinating the plant. But the moth also, while pollinating, the moth lays its eggs in the flowers. So, young [moths] depend upon the developing fruit of the cactus that their mother's pollinated, which makes it a bit of a tug-and-pull relationship for the cactus. The cactus needs the adult pollinators, but it also pays a small price in giving away some of its developing fruit. So, more moths is good because you get more pollination, but you also get a whole lot more eggs. So maybe it's better, in terms of the abundance of the moth, to have an

intermediate number of moths, so that not too many eggs are laid, but a lot of flowers are still pollinated.

ARA: Right, so it's a tricky balance. And, is that something you're looking at; what is the optimum number of moth eggs?

NH: Exactly. So, we're looking at, in this cactus, does the cactus have any sort of strategy it can employ to keep moths from becoming overly abundant, and what is the consequences of that strategy for moth abundance. And, it turns out that the cactus likely does have a strategy to regulate moth population at levels that are best for cactus reproduction.

ARA: Ok, interesting! So, just so that people have an idea of what kind of animals and plants we're talking about, can you briefly describe what this moth looks like?

NH: It's a fairly drab moth; it would largely go unnoticed if you weren't really paying attention to the cactus. The moth is, maybe, **10mm** [long], is pale in color, and has one little grey stripe, one thin little grey stripe, going down each of its visible wings. It's really a nameless moth in the Sonoran Desert.

ARA: What's the scientific name?

NH: The scientific name is *Upiga virescens*.

ARA: Ok. It's got no common name?

NH: Well, its common name is that of the cactus; we call it the senita moth.

ARA: Oh, ok. Like a yucca moth. And, a lot of people have never been to the desert southwest. It's one of my favorite places, because I think cacti are so neat! So, could you tell us a little bit about the senita cactus and what's its range, and what does it look like, and when does it bloom, and that kind of stuff?

NH: Right, so the senita cactus is a columnar cactus and, so it's in a group of cacti that have many, many stems that are like columns, hence the name 'columnar cactus.' And it's one of four species that are occurring in my main study site in Sonora of Mexico. Columnar cacti, in general, are, if we've watched some old John Wayne movies from way back when, we'll remember seeing those images [of cacti] with one arm up and one arm down. And, the senita is a little different from that cactus, which is the saguaro cactus, in that the senita cactus will have many stems that radiate from the base of the plant. These stems can range in number from a young plant that might have 15 or 20, to an older plant that might have 100 or more. And these stems can get up to **4 and 5 meters** in height. So, they get very tall.

ARA: So, that's like 15 feet. Wow! Yeah! so what's the range of the senita?

NH: So, the senita cactus, unlike many of the cacti in the Sonoran Desert, the senita cactus is actually endemic to the Sonoran Desert. It's most northern limit is just North of the US-Mexico border, in Organ Pipe Cactus National Monument. There's a place in that park called Senita Basin, and it's named after the cactus. Their southern distribution goes all the way down to the bottom of the state of Sonora [in Mexico], along the Sea of Cortez, the Gulf of California, and barely into the state of Mexico just below the state of Sonora.

ARA: Ok, neat. So, what do the flowers look like, and when do they bloom, and where are they on the cactus?

NH: The flowers are typically located at the tops of the stems, rather than the bottoms of the stems. So, you might have the top 2 or 3 feet of the stem that's flowering. It'll produce dozens to almost 50 flowers sometimes per stem.

ARA: Oh, wow!

NH: The flowers usually are produced anywhere from early April through late July. I've heard of cacti that can produce about 3,000-5,000 individual flowers. The flowers are fairly small, maybe an inch and a half across. The flowers are pale white to sometimes very pink [in] color.

ARA: So, what exactly happens when a female moth pollinates, and then where does she lay the egg; what does she do in the flower?

NH: Well, it's unique because most moths, and most pollinators in general, visit flowers for the incentive of the food resource the flower is providing to the pollinators. So, that's usually nectar and, in some cases, pollen. Well, the incentive for the senita moth to visit the flower is more as a place to lay her eggs than it is for nectar resources. So, flowers don't tend to contain a lot of nectar. So, the first thing a moth will do is pollinate the flower, and it engages in a, what we refer to as specialized 'active pollination' behavior, whereby the moth liberally rubs pollen from her abdomen onto the [plant's] female reproductive part, the stigma. So the females [moths] will then lay an egg, usually on the petals of the flower, before she departs that flower to go on to another flower of another plant. The flower itself opens at night and closes, usually, by the morning, and within 3 or 4 days, the egg has hatched and the larva is crawling into the fruit of the cactus where it's going to eat some of the developing seeds that are the response of the mother's pollination.

ARA: Ok, now, with yucca moths, I know that the yucca flower doesn't ever really open much, so nothing else ever really goes into a yucca flower. Does the senita flower function the same way, or does it ever open up so that something else visits it?

NH: Oh, no, it's quite different. In fact, senita flowers do open all the way up. They're exposed to many different insects and [other] animals. We see insects that eat flowers on the plants sometimes, we see insects that are in the flowers looking for nectar, but they don't find it because just not much nectar's there.

ARA: So, do the flowers have lots of pollen like most cactus flowers?

NH: They're much reduced in size and shape, compared to some of the big bat-pollinated flowers. Those bat-pollinated flowers just have copious, copious amounts of nectar and pollen. These flowers are smaller and have much less pollen and much less nectar.

ARA: Right, so even though other things visit it, the senita moth is the only one that pollinates? Or is it the only one that pollinates effectively? Or, how does that work?

NH: It's largely the only pollinator. There are a few co-pollinators; some small, beautiful bees, called Halictid bees that in the morning hours, just around sunrise, can visit the flowers and do a little bit of pollinating. Our experiments show that these bees are largely unimportant [to pollination] for two reasons:

1. One, the bees visit the flowers after the moths, and so the moths have already done the job,
2. And two, often because it's hot in the Sonoran Desert, often the flowers close before sunrise; the bees are unable then to access the flowers.

ARA: Right. What are some particular challenges involved with this research?

NH: Well, Athena, there are always professional and personal challenges. One of my personal challenges is not eating too many fish tacos in this beautiful fishing village that I work in. That is a true encumbrance. But, realistically, some of the challenges posing scientists as a whole now are the same challenges that are posed to me as an individual investigator, and that's having enough financial funding to get out and do the research to help provide the intellectual material for the textbooks for our children. So, you know, it financially can be expensive, and it's important for our government to continue to support such funding. In a more practical sense, my work occurs at night, at late hours, and as I get older being up at 2 in the morning and working with pollinators isn't as easy on my body as it was when I was 25 so, sometimes the nocturnal work can be challenging. And then, being in the desert for me isn't a hardship or a challenge, though some people find the desert environment a challenge. I actually find the Houston humidity more of a challenge than I do the dry desert heat.

ARA: (Laughs) Ok, so what do you like most about it, besides the fish tacos?

NH: (Laughs) Well, for me it's really into nature, and being able to look at some really important, fundamental questions that will help us to understand how nature operates, and to be able to collect data, learn about a system in nature that might apply to other systems and to mutualism and pollinators in general. So, it's a lot of the intellectual work and then just being in the desert at night and, while it can be tiring, it is also just an incredibly beautiful place to be anywhere in the world at night- absolutely gorgeous. There's not a lot of light, there's lots of starts, and the silhouettes of cacti against the moon, and when you take a moment to enjoy those scenes,

between your looking at the flowers and the moths and collecting the data, it's really quite tranquil.

ARA: Right. So, I try to, in all the podcasts, relate the research to the general public somehow, so that people will understand, "Well, why should I care? Why should the government spend money on this moth in Mexico? What does that have to do with me?" What kinds of things would you tell someone that you met eating fish tacos that this relates to them and their life?

NH: Right, so that's a really good question, and it's a really important question, and I think the answer is probably best conveyed via analogy. We talked earlier about how this is a one-to-one relationship and an obligate relationship. And, in this particular case, if you went out at night and didn't know the moth existed, you probably wouldn't recognize that it was there and around doing much of anything. In many cases, this is true of many nocturnal, and in particular, moth pollinators, because the moths aren't the charismatic species that lots of people want to reach out and say, "Wow!" And, we often don't see them and notice them because they are occurring at night and they are typically less beautiful than the diurnal butterflies. But this particular moth, as an example, can be analogous to the small pieces in a mechanical watch. So, you can imagine yourself opening up the back of a watch to change its battery, and you can see some important pieces. You know that if you remove one of those important pieces, that the watch is going to stop working and we just aren't going to be able to know what time it is. But there are also other little pieces down in that watch that you can't really see, and those are analogous to this particular moth, and many moths in general that are important pollinators. Whereby, if you remove the moth, or that little small piece in the watch that you don't see, then the system, the watch or the ecological system as a whole, can start to break apart, and so would some of the things that society depends upon, as a whole, can diminish.

ARA: Nice!

NH: So, many of these cacti, for example, and the senita cactus is one such example, produce fruit that are very good, and enjoyable, and some indigenous as well as local people use and consume and make jelly out of [it]. So, if we lost the pollinators, the moth pollinators, then we would no longer have some of these wonderful jams and preserves that are bought in Mexico or in Arizona that people will send as holiday gifts to their relatives.

ARA: Yeah. So, like the saguaros, the senita was probably [an] important food resource, and maybe a textile resource for the dead spines, to native cultures, before European settlers got that way.

NH: Exactly, exactly.

ARA: Cool, ok. What would you recommend to people who want to help pollinators in general, or moth pollinators specifically? Do you have any recommendations for things people could do?

NH: Yeah. There's always non-profit organizations that will accept donations, and that also fund research. You know, like in the Sonoran Desert there's the Arizona-Sonora Desert Museum. I guess for pollinators in general, for someone who might be interested, I would actually recommend a book that came out, I want to say just a few years ago, but now that I think about it, it's probably been over a decade now. But it's a book by Dr. Steve Buchmann and Dr. Gary Nabhan called The Forgotten Pollinators.

ARA: Yeah, it's actually been more than a decade, it's hard to believe, isn't it? (Laughs)

NH: So, I don't know if we're aging ourselves... [but] so, that's a really great resource for just enjoyable reading and education on pollinators as a whole that's written to the scientist and to the non-scientist alike, and it's just a wonderful read. So, I highly recommend that, and that has some resources within it to direct people to how they can help with pollinators.

ARA: Something that I like to always encourage people to do is plant a native garden, with native plants! If you're lucky enough to live in the southwest, you know, if you look for all kinds of fun cacti and other succulents, and just native wildflowers, you're going to be providing food to, maybe not the senita moth if you don't live in its range, but pollinators that'll visit those plants at night and pollinators that'll visit those plants during the day... So, something that I try to get people to do is think about natives when you're planting.

NH: Absolutely, absolutely. And I think that what you're suggesting, Athena, is really appropriate for wherever you live, whether it be in very cold parts of Alaska, or whether it be in the humid summer months of Athens, Georgia or Houston, Texas, we can engage in something that Dr. Mike Rosenswag at the University of Arizona refers to as reconciliation ecology. And, that is sort of doing backyard ecology- to utilize our own yards to put in native plants that help, in urban areas, the local natural resources, such as moth pollinators, to be able to continue to persist. That's really an important point you've made.

ARA: Yeah. Ok, well thank you so much for your time today!

NH: Thanks very much, Athena! Good luck with your projects and your work- I'm really pleased to know that somebody's out there doing what you're doing.

ARA: Once again, you've been listening to pollinators.info podcast episode 4. I'm Athena, the author of pollinators.info, and this was an interview with Dr. Nat Holland, who studies senita moths and their obligate mutualism with the senita cactus in Mexico. Stop by pollinators.info to learn all kinds of neat stuff about pollinators, and the plants that they visit, and how you can help pollinators. And join the Pollinator Conservation Movement by signing up for the free weekly pollinators.info email newsletter! And, did I mention you'll get free stuff? There's free stuff! There's free stuff now, AND there'll be more free stuff in the future! (Laughs) So, once again, thanks for joining me, and stay tuned for next month's podcast. Take care!