

You're listening to Fungi Town and this is Episode 12: Ergot A Better Title?

[Fungi Town theme music]

[0:00:15] Welcome to Fungi Town, where we get earnest about ergot, wonder about witches, and learn about LSD. I'm your host and mayor of Fungi Town, Jen Parrilli. Today, we're going to learn about grass and talk to Dr. Anthony Glenn of the US Department of Agriculture about the plant pathogen known as ergot of rye.

[0:00:34] Grass. It might not seem like a big deal. Well, at least until you have to mow your lawn.

[lawn mower]

But grass is big business. The landscaping industry last year, earned over \$80 billion dollars and there are now over a half million landscaping businesses in the United States alone. Think about sports fields.

[baseball hit]

The cost to install and maintain a natural grass baseball infield can be hundreds of thousands of dollars. Although there are only two major league baseball fields left that use natural grass, imagine all of the little league fields, softball fields, and soccer fields in this country alone, not to mention parks, greenways, and yards.

[grasswalk]

[0:01:24] When I say "grass," the first image in your mind might be something like Kentucky Bluegrass, Bermuda Grass, or even Crab Grass - those short green plants covering the lawns we just talked about. The family Poaceae, or grasses, however, includes over 10,000 different species and is way more diverse and important than you or I might give grass credit for. Encyclopedia Britannica's entry on the topic says that grasses are "the world's single most important source of food." Maybe eating grass doesn't sound that appetizing, but when you eat bamboo, rice, wheat, barley, rye and oats, you're eating grass. Well, most of those are the seeds of the grass, but you catch my meaning. Ironically, the drug people sometimes call "grass" is not a grass at all, but more closely related to nettles.

[0:02:16] Grasses, like a lot of plants, form flowers before they can make seeds. When a flower is blooming, the female flowers are waiting for pollen from the male flowers. Some of this pollen gets spread by wind, and some by insects, but when it *does* reach the female, that tiny little bit of pollen travels down a part of the female flower aptly called the pollen tube. Down at the end of that tube is the ovary and the embryo sac. This is where fertilization happens. After that, a seed happens.

[0:02:50] We'll get to the all-important fungi connection to this process, talk about LSD, and even discuss witches, when I talk to Dr. Anthony Glenn after the break.

**[0:03:00] Break:**

I *love* my guests. Fungi Town wouldn't be the same without them. Despite busy schedules, they take the time to share their expertise and enthusiasm with us. So I like to show my appreciation by sending them a hand-written thank you card. In an age of instant connectivity, it feels pretty special to get a surprise in the mailbox, something you can hold and touch, something the sender put care into. But, sappy, mass-produced grocery store greeting cards are *not* for me. That's why I order all of my notecards from Haley at Lichen Landscapes.com. Each card set features four gorgeous, hand-drawn illustrations of different lichens. The cards come in several beautiful designs and are blank inside so I can customize my message. Not only can you find card sets at Lichen Landscapes.com, but you can also order Haley's lovely lichen prints. They're a great way to show your fungi love. So get on over to Lichen Landscapes.com and discover your favorite design! And when you enter "fungi town" in the notes portion of your order, a percentage of your purchase will go toward supporting the Fungi Town podcast! So what are you waiting for?

**[0:04:10]** [Lost & Found podcast ad]

**[0:04:48]** Welcome back. Before the break we learned a little about the importance of grasses. To get an professional point of view, I went to the United States Department of Agriculture to talk to a grass pathogen expert.

I'm Anthony Glenn, and I work for the U.S. Department of Agriculture, Agricultural Research Service in Athens, GA. I'm in the Toxicology and Mycotoxin research units. And I got my PhD from the University of Georgia in 2001. I'm originally from Alabama.

**[0:05:19] What do you study here?**

AG: So the research unit is a food safety based research unit. And so within that context it's focused on metabolites produced by fungi, secondary metabolites produced by fungi that have adverse impacts on animals and humans if they're ingested as part of a crop. So our main crop of focus is corn, and looking at fungi that infect corn, and then produce these toxins that can end up in either human food or animal feed.

**[0:05:55] But you've also studied *Claviceps*.**

AG: I have. My master's work was on that family of fungi, the *Clavicipitaceae*. So that's kind of how my whole interest in all of this got started. It goes all the way back to my undergraduate days, working in a lab at Auburn University at Montgomery, at the branch campus with Dr. James White. And so I had the opportunity as an undergrad to work in his lab. He was an exciting guy, very good teacher, and it kind of got me interested in it. And working on, he was looking at these endophytic fungi, so fungi that live within plants. And these fungi were part of this family, this *Clavicipitaceae* family. And so from there I got interested in the genera of *Balansiella*, *Epichloe*, *Myriogenospora*, *Claviceps*, all part of those things.

**[0:06:49] And the *Claviceps purpurea*, that's the ergot producing fungus, right?**

AG: Yeah.

**[0:06:56] I understand that it mostly, that it's a grass parasite, or a grass pathogen, but that it mostly affects rye?**

AG: So, *Claviceps purpurea*, there are a few dozen some odd species of *Claviceps*. *Purpurea* is the one that's most commonly known, or studied, or read about. And it can infect hundreds of different grasses. But rye is the one that's kind of historically most well known in terms of being a host for *Claviceps*. But it can affect wheat, and, like I said, hundreds of other different grasses as well.

**[0:07:35] So do we care about the rye because we eat rye?**

AG: The rye ends up being an important one historically because of serendipity, I guess, to a certain extent. Because I think the life cycle of the plant coincides really heavily with the life cycle of the fungus. So the plant's biology just sort of, I think, lends itself to being infected by *Claviceps*. The intensity of an infection and the resulting manifestation of the infection are kind of driven by the plant itself to a certain extent. So the size of the seed that are normally, or the size of an ovary of a particular plant will result in bigger sclerotia from *Claviceps*. Because it infects the ovary, and then where you would normally have a seed produced you have these *Claviceps* resistance structures called sclerotia that are produced there. So I think it, rye, this happens to be sort of a history of circumstance, which is why it's mainly talked about.

**[0:08:37] I know with corn smut, the *Ustilago*, the fungus creates like a mutation. It causes the kernels to mutate so that it has more material. Is it similar at all?**

AG: It's sort of similar in the case of smut it's, the kernels get infected. And then the kernels, the development of the kernel changes, and then it's eventually taken over by the fungus and you have the gall produced by the fungus. In the case of *Claviceps* what happens is the... So at the same time the grass is flowering, the fungus is producing spores, ascospores, the spores resulting from sexual reproduction. And the ascospores land on the stigma of the grass. And then the fungus germinates, grows down, and infects the ovary of the grass. So it's called a replacement disease. You don't really get a gall form like you do with *Ustilago*. But instead that ovary gets colonized, and instead of having a seed develop there, the fungus grows and produces something that looks like a seed, but it's a fungal structure, entirely a fungal structure called a sclerotium.

**[0:09:54] So does it enter the flower through the same pathway that a pollen grain might?**

AG: Exactly. Yeah, exactly.

**[0:10:02] So how do those initially infect the plant? Are they soil pathogens? Like, are they in the soil?**

AG: Yeah, so the sclerotia are these black, highly resistant structures that look like seed. So they, to kind of take a step back, in terms of the life cycle, the sclerotia are produced instead of a seed at that location within the ovary. The sclerotia will fall off at the end of the season to the soil, and overwinter. And then overwinter and then in the spring they germinate. The sclerotia germinate and it's kind of the same sort of process. But they'll germinate and produce what's called a stroma. And then inside of that you have ascospores that are produced. So at the same time when the plant is flowering, these ascospores are being produced, and then being released, and then infect the developing flower of the grass. And then that process starts, and the infection process starts.

**[0:11:16] Okay. So, how are animals and people affected by the fungus?**

AG: So, the sclerotia that are produced are loaded with these secondary metabolites, these mycotoxins. They're called ergot alkaloids, ergot because that's what the fungus is called, and then alkaloids, because that's sort of a general term for compounds that have a lot of nitrogen atoms in their structures. So these ergot alkaloids are produced, and I think *Claviceps* can produce around 70 different types of ergot alkaloids, so it's, we talk about them...

**[0:11:54] It's a range of things.**

AG: Yeah, exactly. We talk about them all as one sort of collection, or one type of metabolite, but really there are dozens of different compounds. Some of them cause constriction of blood vessels, so they have this vasoconstrictive effect on animals and humans. Some of the ergot alkaloids can have more of a neurological effect, or a muscular effect, so you get hallucinations, you get muscle contractions. So between the blood vessel constriction, which can result in gangrene if you ingest enough of it, combined with neurological, you get this perfect storm of possible impacts on animals and humans.

**[0:12:47] Now are animals... Say a horse eats it. Are they affected the same way that humans are?**

AG: More or less as far as we know, at least from the vasoconstrictive part. The neurological or hallucination part, not so sure. But yeah, I think the basic, these compounds have an antagonist interaction with various different types of receptors, whether it be a blood vessel receptor, a muscle receptor, or what have you. So I think some of that basic physiology is the same.

**[0:13:20] Well, we're all mammals, right?**

AG: Right, right.

**[0:13:23] So basically if you eat this ergot fungus, you may have hallucinations, and spasms, and get gangrene and have your limbs come off?**

AG: Right.

**[0:13:35] So that's not something that you intentionally want to eat.**

AG: Right. Exactly.

**[0:13:40] I guess because there was a higher chance of people getting poisoned, or being affected by the toxin because they were maybe storing grains, or... Can you talk about some of that?**

AG: Yeah, so some of the other... The storage isn't, wasn't so much of an issue with Claviceps. Some of the other fungi that I've worked with, like *Fusarium* and *Aspergillus*, storage does come into effect. But with Claviceps, because it's a replacement type disease, so instead of a kernel getting made, you get these sclerotia made. The sclerotia end up being harvested with the grain. And so before the 18<sup>th</sup> century, really, or 19<sup>th</sup> century, we really didn't know to separate those sclerotia from the grain. So the sclerotia would get milled in with the grain to make the flour. And that led to the inadvertent consumption of the alkaloids coming in. Because again, the sclerotia are really loaded with these alkaloids. So that's kind of how that exposure happened. So it wasn't so much about storage as much as just not knowing to separate the sclerotia from the regular grain.

**[0:15:00] Like say if you're breaking bread with this rye, does the heat from the baking affect these secondary metabolites?**

AG: It can affect some of them. Some of them are more stable than others. But they're still pretty stable, pretty hardy compounds. So yeah, they would still pass through that baking process.

**[0:15:17] There are a few significant historical things that have been tied to Ergotism. And I've heard conflicting stories about what may or may not have happened. So Ergotism is also called St. Anthony's Fire, correct?**

AG: Right. Right.

**[0:15:38] Wasn't there a monk, or a group of monks that went around helping people with this?**

AG: Yeah, so it's tied to St. Anthony, and there are a couple of different St. Anthony's. This St. Anthony was the one, he was an Egyptian monk who is credited with being the first, the creator or the father of the monastic way of life, sort of separating yourself from society. In his case, going to live in a cave. And that was in the 1<sup>st</sup> century AD. He came to be associated with this disease during the Crusades. So during the Crusades his relics were brought back to France and enshrined there. And there was a nobleman, who he and his son came down with a disease, so he went and prayed to the relics of St. Anthony, that if he would be spared they would dedicate their life and their fortune to helping others with this affliction. And low and behold he was saved, and that's how St. Anthony became associated with the disease. I think prior to

that he'd also been associated with leprosy and other things. But that's how he came to be associated with Ergotism. And after that it became known as St. Anthony's fire.

**[0:16:50] And the fire part comes from some of the symptoms it makes, right? Is that the vasoconstriction?**

AG: Yeah, so the ergot alkaloids as I mentioned, there are two main types of symptoms associated with them, and one of them is the vasoconstrictive gangrene symptomology, that results from ingesting the alkaloids that cause the blood vessel constriction.

**[0:17:14] Okay, but the gangrene is sort of a secondary thing that happens because of the vasoconstriction?**

AG: Yeah. So you have, right, so you have the blood vessel constriction, and if you ingest enough of it, enough of those alkaloids in high concentration or high frequency, then the gangrene will set in. And it's supposed to be, I can't even really envision what this must be like, but it's supposed to be a dry gangrene. So literally the extremities will just dry up and fall off. So it's not a bloody, gorey...

**[0:17:47] It's not one of the like, ooze gangrenes.**

AG: Yeah. Yeah.

**[0:17:51] Is it being used at all currently in the medical field?**

AG: So the alkaloids, or at least their semi-synthetic derivatives are being used. Going back to the '30s with a Swiss company, Sandoz, they started looking at these compounds for various pharmaceutical purposes. But yeah, even today, I'm not sure how extensively they're used, but they have been used for migraine treatments because again, the vasoconstrictive... If you can control the vasoconstrictive process, you can help alleviate some of the pain associated with migraines. And if you can control the muscle contraction aspect, then that can be of assistance during childbirth and those sorts of things. And then I think there are even some aspects that are being helped or looked at in terms of dementia.

**[0:18:47] And speaking of things that are synthesized from fungus, I know that lysergic acid is found in ergot. It has to be synthesized in order to produce LSD, right, which is lysergic acid diethylamide?**

AG: Correct, yeah.

**[0:19:03] But LSD isn't in the fungus?**

AG: Correct. LSD is not in the sclerotia. But LSD was synthesized or derived by a chemist named Albert Hoffman working for Sandoz. In 1938 he was working, taking lysergic acid and was doing various modifications with it, to see if he could enhance its pharmaceutical value

and efficacy. And in the process ended up adding on this diethylamide, amine compound, and created LSD. And discovered accidentally its effects...

**[0:19:49] And skin absorption?**

AG: Yeah, exactly. The funny thing was, it was synthesized in '38, and first sort of tested and found that it really didn't have the properties that they were looking for. And so it was put on the shelf. But then several years later he came, and I don't really know if anybody knows exactly why. I'm sure it's recorded somewhere. But anyway, he came back and resynthesized it out of some sort of curiosity. And in the process got a little bit on his fingers and absorbed it and had to go home. He was having ... about 30 to 60 minutes later he had some strong reactions and had to go home. But then he got curious, and a few days later on April 19<sup>th</sup> he, what's kind of known and today as bicycle day in the counterculture, I guess you could say, he decided to resynthesize it, or not to resynthesize it, but purposely to test it on himself. So he calculated a dosage and dosed himself. And again, found he had to go home. But he needed some assistance getting home. So his assistant went with him and it was World War II going on, so there were no cars really available. So he had to ride his bicycle home. And anyway, that's kind of become known as Bicycle Day. But the funny thing is, it turned... And later the reverse, the calculations were redone, and it seems that he probably overdosed himself by 10,000 fold, what would be considered the "recommended" dose. And yeah, it's no wonder he had such a vivid reaction.

**[0:21:40] Yeah, that would be mind bending.**

AG: Yeah.

**[0:21:46] So, if LSD is something that has to be synthesized from the ergot, why do people have hallucinations when they eat the rye that's infected that hasn't been synthesized?**

AG: Yeah, I think, my understanding is that sort of the nature of the hallucinations is a little bit different. And, you know, with LSD, if you're not doing a 10,000 fold dose, it's supposed to be more of a euphoric kind of hallucination. Whereas with the ergot alkaloids it's more of a tormented kind of situation. And my... It's a little bit of hand waving here, but my understanding is it really will relate to how the... Each individual person is different. The dosing obviously has an impact. These compounds are really complex. They're relatively small, but they're still chemically intricate compounds, and so they can fold and bend in different ways. And so how that impacts how they interact with receptors and all that gets into the biochemistry. But basically I think the point is, it depends on the dose, it depends on the person, it depends on your susceptibility to the toxin. All those things combined and you get, you still get an affect, but just not as, I guess pure an effect as you would get with the LSD.

**[0:23:21] And LSD, as far as I know, doesn't have a tendency to cause gangrene.**

AG: Exactly. Yeah, yeah, exactly. And that's the pure aspect.

**[0:23:30] It's just that one compound, right?**

AG: Yeah.

**[0:23:33] Obviously we still grow rye. Currently, how do we control the ergot issue?**

AG: Yeah, so it wasn't until I think the 1760s before it was figured out that the sclerotia were what was causing the issue. So we've had now almost 300 years to figure out other ways to control it. But it turns out hygiene and cultural practices when farming are probably the most effective way. For example, when you plant a field of rye, if you control the weedy grasses that are around the field which might be susceptible to ergot, and could be reservoirs for ergot, so if you control the surrounding weedy grasses then you can limit the infection of your crop. Growing a good healthy stand of your crop is a great way. If you have a healthy plant you'll typically have less infection. And other sort of cultural practices, sanitary practices. If you know you've got some ergot out there, but maybe it's isolated to the edges of your field, then you may plow those deep into the soil so that you get rid of the sclerotia. That sort of thing. And then now there's even some breeding efforts, so breeding or from a genetic perspective, getting resistance to the disease as well.

**[0:25:04] And I imagine that after they've harvested the rye maybe there's some type of quality control.**

AG: Right, during the harvesting then you can manually separate any sclerotia from the grain. That gets a little difficult just because of the sheer bulk of grain that you're dealing with. So if you can minimize the number of sclerotia going into that harvest then that's best. And then there's some the monitoring that goes on afterwards.

**[0:25:37] It's time for de-funked, a segment where I debunk fungi myths and misconceptions. As if the history of ergot wasn't interesting enough, there are some indications that ergotism may have to do with another infamous historic event. But are the rumours true?**

**[0:25:53] I've heard conflicting stuff about like some of the Salem Witch Trials being associated with Ergotism. So I've heard that it was associated, and then I've also heard that that's a myth.**

AG: Yeah, it's one of those things, there's no hard, concrete proof. All you can kind of go off is anecdotal evidence. So, you know, it depends on how comfortable you are with a little bit of creative freedom, I guess. But yeah, the reports in terms of the people were ingesting rye bread, apparently during this time frame. The environmental conditions apparently were conducive to what you might, conducive to the development of an ergot outbreak in the rye. The symptoms are definitely consistent with what you would expect with Ergotism in terms of the hallucinations, the convulsions, the dementia and other sort of manifestations. So for those reasons it's thought that it might be associated with the hysteria that developed out of that.

[0:27:12] That wraps up episode 12 of Fungi Town. Thanks to Dr. Glenn for sharing his ergot expertise and to Rowen Cannon for providing transcription.

[0:27:22] Fungi Town is written, edited, and produced by me - Jen Parrilli and hosted by Podbean. The theme song is by local Athens band Shehehe. You can find all of their awesome songs on their BandCamp page at [Shehehe.bandcamp.com](http://Shehehe.bandcamp.com). Episodes of Fungi Town are released every other week. Be sure to subscribe so you don't miss the next episode, where we talk about fungi and frogs. You can join the conversation and share your fungi photos with Fungi Town on Facebook, Instagram, and Twitter @fungitownpod and now you can check out Fungi Town on YouTube. Once the channel reaches 100 subscribers, I'll be doing a fantastic fungi giveaway! If you like this podcast, please subscribe and leave me a review on iTunes. This goes a long way toward helping more people find their way to Fungi Town. Thanks for listening!