The Fields Guides : Episode 39 The Alliterative Purple Pitcher Plant (Carnivorous Series #1)

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[Sound of footsteps]

Bill Michalek: Hello! And welcome to The Field Guides. I'm Bill and I'm here with Steve. Good afternoon, Steve. **Steve Fleck:** Good afternoon, Bill.

Bill: What we're going to do today and over the course of many future episodes is give you the experience of what it's like to be in the woods, in the field, and on the trail. Each month we pick a natural history topic, research the science behind that topic, and get you out in the field to share with you everything we've learned. But over the past month, I have not learned anything. [Laughter] It's up to Steve to entertain us with what he has learned.

Steve: Yeah. So last time I did an episode, I talked about a chunky little bird, right?

Bill: Oh, the woodcock.

Steve: Yeah, the woodcock. So this time, I'll be talking about a chunky little pitcher plant, *Sarracinea purpurea* - the purple pitcher plant. And as you'll find out, there are many different groups of pitcher plants and we'll have to sort those out. So here's the plan: I'll talk about carnivorous plants, then we'll talk a little bit less broadly about the groups of plants that are considered pitcher plants (some of which are actually surprising), and then I'll talk even less broadly about the pitcher plant family we have around here in the Western Hemisphere, the Sarraceniaceae. And finally I'll dig into some interesting aspects of the species that Bill and I will be seeing today, *Sarracinea purpurea (*the purple pitcher plant), which is the most common and broadly distributed pitcher plant as well as the only member of the genus that inhabits cold, temperate climates.

Bill: And I'll just be providing off-color commentary.

Steve: Yeah! Not TOO off-color, Bill.

Bill: So for those of you who I think might be your first episode of the podcast, I think we should say that for the last few episodes Steve and I have been trading off research duties. So one person does the research; the other person comes along for the ride (pretty much in the dark about what we're gonna be covering), and that has been working out pretty well for us.

Steve: Yeah, I think the origin of it was a mid-semester crisis where I was like,

"I can't do it, Bill. I can't do it, man, not this month." And then Bill took it and we've switched on and off ever since.

Bill: Are we going to tell people about where we are right now?

Steve: See, this is tricky because we don't know what we're gonna see and we don't want to endanger any plants, so my thought is that we are in a bog in western New York.

Bill: Because we are in a somewhat sensitive area - ecologically speaking - and we don't want to create a stampede of people through this area.

Steve: Yeah, and while we always encourage people to go see exciting species, there is a lot of responsibility to seeing those species and getting yourself out there and knowing how to really respect the area. So we'll leave it up to you guys to figure out where it is.

Bill: Well, what I would say is that what we've covered in this episode, if you find it interesting, get in touch with a local nature center or botanical club. Find out if they are doing any field trips to a bog in your area because, really folks, if you don't know abut bogs or even if you do and you've never visited a bog, it is really . . . a habitat unlike any you have ever been in before. I think it's a place everybody should visit at least once in their life because EVERY time I visit a bog, it's a trip I always remember.

Steve: Yeah. And I will say if you do go, make sure to brings some like tall rubber boots with you. This is my first time wearing Gumleaf boots of my own. Bill and I are no longer sharing boots and we'll talk about it later in the episode, but I currently have a brand new pair of Gumleaf boots on right now and I was in a bog two weeks ago and just comparing today and two weeks ago . . . you can't compare the two. Just walking so nicely through complete wetness, ah man, it's a totally different experience.

Bill: This will be one of the first episodes recording where I'm not concerned about Steve's footwear [laughter] cuz no matter where we go he always seems to just be wearing sneakers.

Steve: And we should say that Jack Butler is also with us, so say "hi", Jack.

Jack Butler: Hello!

Steve: So he's just gonna be trailing behind us and you'll hear more from him in the ad section, halfway through the episode.

Bill: That's right. So I want to give people an idea of where we're at, though, just in terms of what's around us. So we are on the edge of a forest. There's a clearing in the forest where the vegetation is somewhat lower, and we are on the edge of a muddy trail heading out into the open area. We're gonna be kind of winding our way through this trail. There's already some large logs that people have left down because it is MUDDY and this is the border of the bog.

Steve: Yes. And the bog itself, the reason that we can actually (and we will be walking out in the bog) but the reason we can do that is a) we found a welldefined trail that many people have used before us (so don't just go walking out on bogs and making your own trail), and 2) there's a layer of sphagnum moss that has formed over the bog and there's just layer upon layer upon layer of sphagnum and we're actually . . . it feels kind of like you're on a water bed, but a little bit more stable. Well, you can fall through, I guess, but it's a more stable waterbed, it feels like. And it's just you're on this large floating dense mat of sphagnum moss and that's what everything out here is growing on. We have some tamarack, also (what do people also call that?).

Bill: Uhh, larch.

Steve: Larch! Yeah. The deciduous conifer.

Bill: That's it.

Steve: And we're also gonna see a number of members of the heath family, but we're also gonna talk about that later.

Bill: Before we get started, I feel like we need to do a very brief (if it's possible) introduction to what a bog is.

Steve: Sure!

Bill: It's a highly acidic environment. There was some depression that over time has slowly started to fill in, but there's very little outflow or inflow into the depression. Things start to pile up. Sphagnum moss, once it gets a foothold, starts to form (as Steve said) a mat across the top, so it's a nutrient-poor habitat, but since it is nutrient poor, you get these unique species that have evolved to live in this nutrient-poor environment. Decomposition happens very slowly because it is so highly acidic underneath the mat. The temperatures beneath the water are usually very cold and since it . . . I feel like I'm saying "highly acidic" a lot. [Laughter] But that is a big part of a bog.

Steve: Yeah!

Bill: So you get things like pitcher plants and sundews – these carnivorous plants that maybe you've heard about before.

Steve: Yeah.

Bill: Is that a good summary?

Steve: Yeah, I think it's fine. Acidic, standing water, sphagnum moss – you basically hit all the points.

Bill: Eventually what can happen in a bog (since there's very little inflow or outflow) the mat can get thick enough where it actually hits bottom and then it will become a meadow and then be reclaimed by the forest. That's what CAN happen but it takes a very, very, VERY long time.

Steve: Alright! So I think to begin with, let's just define what a pitcher plant is. So it is a carnivorous plant and because we haven't really talked about carnivorous plants before, I think it's worth briefly exploring this group in general.

What makes these plants different than non-carnivorous plants? In short, these are plants that eat animals. I mean, I think that's the most simple way to say it. Typically, we think of plants as producers and animals as consumers. Plants are immobile and they need to defend themselves against animals (both physically and chemically) but there's been at least eight hundred species of the over three hundred fifty thousand flowering plants that have gone against the grain and have decided to become predators themselves.

Bill: "Decided".

[Laughter]

Steve: You're gonna hear a lot of language like that throughout the podcast, so I'll try to be careful but I'm sure Bill will jump down my throat.

Bill: That's why I'm here.

Steve: These immobile predators are called carnivorous plants. And in terms of the name, *carnivore* just comes from the Latin *carnis* and *vor*, roughly translating to *flesh swallower*. They also eat insects, but they also go after some larger prey, as well. In terms of the carnivorous plant diversity, there are currently nineteen genera of carnivorous plants that represent at least ten independent origins for carnivory within the flowering plants. This isn't something that happened once. This happened completely on its own ten times that we know of throughout evolutionary history. One really important thing about carnivorous plants is that they get most of their nutrients from animal prey in sometimes vastly different ways. I plan on covering some of these other carnivorous plant groups in upcoming episodes, but I want to give a brief preview to three different groups in our area, just so we have something to compare the pitcher plant to -just a really, really brief overview. So sundews (that's something we're actually gonna be seeing today) these have leaves that a covered in really short little hair called *tentacles* and they're tipped with balls of sticky dew, and maybe a prey species like an insect will get stuck on that dew and then the leaf will slowly roll up around them and digest them. The venus fly trap, that's probably the best know carnivorous plant. These guys have modified leaves that actually kind of look like open jaws. And when an insect, for example, is on the leaf (the open jaw area) and meets the right requirements, the trap will rapidly snap shut and catch and digest the prey. And lastly, the bladderworts, these guys have small bladders that grow under whatever substrate they're growing on. These can be aquatic or terrestrial species, but the aquatic species have the largest and most obvious bladders, so when a prey brushes against the traps' trigger bristles, the bladder will actually suck them in extremely quickly and digest them.

Bill: It's incredibly cool.

Steve: Oh, yeah! I think it's like 0.06th of a second, something crazy. It's super, super fast. So we'll hopefully get to all of these groups in more detail in future episodes but I just want to give a quick explanation of three other mechanisms that plants have for eating animals, and I think it really will be useful for comparison with pitcher plants throughout the episode. I think it's important to go a little more in detail of what makes a carnivorous plant a carnivorous plant. And there's something called the *carnivorous syndrome.* That's defined as catching or capturing prey in specialized, usually attractive traps,; killing the captured prey; digesting the prey; absorbing the nutrients from the killed and digested prey; and then using these metabolites for growth and development. Only plants that possess all five of these traits can be considered carnivorous.

Bill: Really?

Steve: Yes. Interestingly, pitchers plants have another trait, and this attraction and retention of prey. These traits can be useful, but it's actually not required for carnivory. Just if the chance of it happening is enough, that's all that you really need for a carnivorous plant to be successful – is that just by chance it'll land there. So other plants that I really won't get into: the corkscrew plant and bladderworts are kind of like that. There's nothing attracting them towards the trap; it just kind of happens on it's own.

Bill: Okay.

Steve: So lets think back to those five traits really quick. So I'm not sure you notice but I said that carnivorous need to be able to KILL the captured prey. And they're just not passively waiting for the animal to die before digesting it. This means that carnivorous plants are different from saprophytic plants.

Bill: Ah, alright. So you're opening up a whole 'nother realm here.

Steve: These are plants that let's just say it simply; they just absorb decaying biomass. That's as far as we need to take it and that's not what carnivorous plants are doing. Sure, they're doing that but they're the ones killing it. They're just not finding something dead inside of them.

Bill: Now, correct me if i'm wrong because all of my previous naturalist training, when you say saprophyte I automatically think of . . .

Steve: Fungi?

Bill: No, I automatically think of . . . indian pipe!

Steve: Oooh! Got it.

Bill: But hasn't it been found relatively recently that indian pipe is NOT a saprophyte?

Steve: [Long pause] I don't know.

Bill: Alright. Well I don't know about that but we should mention that we are going to be doing an episode on indian pipe. Someone did recommend that we do an episode not that long ago. So I just want to let that person know, "We heard you and it's on our plate."

[Laughter]

Steve: I take it that that is going to be Bill's next episode.

Bill: That's a good idea!

Steve: Hey, if it's a plant I'm fine with it. So in terms of digestion and mineralization, this is actually done in one or two ways by pitcher plants. It's either done by releasing their own digestive enzymes or relying on trap commensals, A.K.A. Digestive mutualists.

Bill: Oo, that'd be a great band name, "Digestive Mutualists".

Steve: So while most of their nutrients typically comes from prey, many carnivorous plants can also acquire organic and mineral nutrients from detritus, pollen, algae, or microorganisms. So it doesn't just need to be things that they actively trap. Sometimes something will land inside the pitcher, for example.

Bill: Yeah.

Steve: I wanna just briefly touch on the habitat; we already got into it a little bit but obviously we're out on a bog right now.

Bill: We're not out on the bog yet. I've been waiting but you're still talking.

Steve: You have ONE foot out on the bog. [Laughter] If you wanna go out in the bog, we can move closer to the bog, Bill.

Bill: Alright, why don't we head in a little bit because, folks, I'm sure as you're hearing it's a little bit windy today so we are picking up some wind noise on the mic, but we're hoping as we get out onto the bog it might not be quite as bad because we're getting a lot of leaf noise especially.

Steve: We're right in a path here, too, so I think when we get into a shrubbier area we might be better off.

Bill: So you're gonna hear us walking through the mud here folks. [Squishing footsteps] Whoa!

Steve: Oo! Bill just sunk in!

Bill: [Laughing] Good think I had my boots on!

Steve: It's like a water bed.

Bill: It is.

Steve: Okay, correction. Bill and I are on a bog NOW.

Bill: Yes.

[Laughter]

Steve: So this kind of wet, nutrient-poor and unshaded habitat is common across the board for carnivorous plants. And a good question might be "Why?" Why do they prefer these types of environments? So, Bill, do you wanna guess why they're out on a bog?

Bill: Well I think it's cuz there's not as much competition out here.

Steve: Yeah. Okay, so I'll really glad that that's what you said. In fact, that's what I predicted you would say in my notes.

Bill: Am I wrong?

Steve: Based on what we know right now, that's saying too much.

Bill: Okay.

Steve: Which is surprising to me, cuz that's the answer I would have given before reading what I had to read for this episode. So there have been some competition experiments where carnivorous plants were grown in more nutrientrich soils without competing non-carnivorous plants. This led to carnivorous plants re-allocating resources that typically go towards trap production and used them to create increased chlorophyl concentrations in their leaves or create leaves with greater surface area. In some cases this decrease in carnivory with increasing substrate nutrient availability was adaptive, but in other cases, growing the plant in nutrient-rich conditions reduced both trap production and individual plant fitness. So it seems like in some conditions they're doing just fine and then in other conditions, even without competitors they're not doing well. It's not that they're trying to escape competition because they can compete, too. And they've done studies where they have some species with competitors and some without, and it just doesn't really pan out. I think the point is that it's not the same across the board, and those studies don't demonstrate that carnivorous plants are being out-competed by non-carnivorous plants.

Bill: So it might be *part* of the answer but maybe just a small part.

Steve: Right. And it might even be the case in some cases but not others. It's not something that we can really make the case for across the board, anyway.

Bill: That seems to be what usually happens in whatever subject we're looking at.

Steve: It's not something that we can say about carnivorous plants, so we have to be careful about how we say things.

Bill: Alright.

Steve: Another things is that soils are really complicated and there are actually a lot of factors that need to be considered, including the soil nutrition, competition

with non-carnivorous plants, the calcium concentration in the soil, soil redux potential, light availability, water availability, and even something that definitely has changed at least since colonization – fire regimes (that's another thing that has a major affect as well). Currently we still don't know why carnivorous plants are absent from habitats with nutrient-rich soils. There haven't been many studies that include both carnivorous plants and non-carnivorous plants, and that's really gonna be a major key to kinda finding the answers in a major way. So moving forward, we also need to explore traits that both carnivorous and noncarnivorous herbs share that make them vulnerable to competition from woody plants, for example, or maybe why they seem to happily coexist when woody plants are reduced by fire or other disturbances. There are situations where they do perfectly fine and then (like I said) there's not really been studies that look at the competition with woody plants, especially when they're competing for water resources in the soil. This is something that researchers are really gonna have to look to in the future if they're really gonna figure out these problems. In terms of the evolution of carnivory, I'm gonna save going into that in any serious detail in my next carnivorous plant installment; otherwise this episode would be way too long. But as always, I'll just plant a few seeds now so we'll have all these ideas rattling around in our brains in preparation for the next episode. The fact that carnivorous plants even exist in the first place is pretty mind-blowing. But as it turns out, thousands of non-carnivorous vascular plants have sticky, glandular organs that ensnare insects ant most plants can actually absorb nutrients through their stems and leaves. So you're already kind of seeing similarity between carnivorous and non-carnivorous plants; they have similar traits.

Bill: So like carnivorous plants took those existing traits and just expanded on them.

Steve: Yeah, they really ran with them. They sprinted with them. But the big difference is that most of these plants grow in relatively fertile soils whereas carnivorous plants normally grow in nutrient-poor terrestrial and aquatic environments. While this intermittent capture and nutrient-absorption of small prey (such as arthropods, herbivores, and microbial pathogens) appears to contribute very little to the mineral/nutrient budget of non-carnivorous plants, the capture and digestion of prey account to the majority of nutrients obtained but carnivorous ones. That's gonna be another major difference. While they can both do it, carnivorous really depend on it much more than non-carnivorous plants. You might think that that *seems* obvious but I think it's important to consider that it seems that evolution is always repurposing things that were already present. The more you look into evolution, the more that that definitely ends up being the case – that it's repurposing on top of repurposing on top of repurposing. And of course it had to start somewhere, but you definitely see that a lot.

Bill: Now tell me if you're gonna get into this a little later on -

Steve: Probably will. [Laughs]

Bill: But pitcher plants don't HAVE to eat insects, correct? And the reason I'm asking that it because, believe it or not at a local grocery store a few years ago they had pitcher plants for sale in little pots. I thought, "Wow! I've gotta buy one of these!" So I bought on and in the directions it basically said that as long as you keep the proper soil and you water the plant regularly, you don't have to give it insects but it does say that you can throw in insects now and then.

Steve: There are gonna be situations where they don't do much digestion at all. Their roots are capable of absorbing nutrients. Has it ever flowered?

Bill: Oh, I killed it within six months because I'm horrible at keeping plants.

Steve: There's part of you're answer – it died. [Laughter] The thing with carnivorous plants is that (and especially with pitcher plants) in years when they don't flower (and I'll get into this a little bit later) they really don't do much digestion. There will even be things that accumulate in their pitchers but they won't be doing much with it. So . . . it's complicated. That's actually a really good answer. "It's complicated." **Bill:** That's a cop-out.

Steve: Yeah. Alright, so I think now is a good chance that we've covered carnivory and we never have to think about that stuff again, [laughter] but now we're gonna start touching into pitcher plants. This part is maybe my favorite part because I found so many surprising things by looking into this. I thought this was going to be a much more simple episode, but as it turns out . . . oh we have a mouse!

Jack: Out here!

Steve: Yeah, it walked halfway across the path then scooted right back in. Wow. Finally we can move on to pitcher plants ,specifically. Generally pitcher plants have modified leaves for catching prey, known as *pitfall traps*. That's going to be the common theme among all pitcher plants. These traps are passive (meaning that they don't require any movement by the plant to capture the prey), so that's going to be unlike the other species that I mentioned earlier, like the venus fly traps, the sundews, and the bladderworts. Well, I guess the sundews don't move to catch the prey but they move after they capture the prey. Basically, pitfall traps are deep, cup-like traps that are filled with fluid. That cup is both the trap and the stomach, and provides the plant with the majority of the nutrients that it can't get from photosynthesis. So of course from photosynthesis . . . oh, it just ran out again.

Bill: There he is!

Jack: Hey!

Steve: Nice!

Jack: What are you doing out here?

Steve: And it even squeaked as it was running. The cup is both the trap and the stomach. They provide the plant with the majority of the nutrients that it can't get from photosynthesis. Photosynthesis is really going to be involved in a lot of carbons and oxygens and things like that (and hydrogens) but the harder things like the nitrogen and the phosphorous, those are the things that it's gonna get from its animal prey. There are actually many groups of species that fit this general description and I spent way too much time thinking about how I wanted to talk about this, but against my better judgment and my own interest I decided to skip the phylogenetic stuff for the most part.

Bill: Thank you, Steve!

Steve: Don't say thank you just yet. The major takeaway is that there are four major groups of pitcher plants, 130 to 160 species in the Nepenthaceae, 35 species in the Sarraceniaceae, one species in the Cephalotaceae, and mindblowingly there are three species of bromeliad – two in the Bromeliaceae, and one in the Eriocaulacaea that are also carnivorous. And if you're not familiar with bromeliads, the foliage can either be very thin and needle-like to broad and flat, and typically grows in like a basal rosette. Many of you might have *Tillandsias* (those air plants growing in your home; that's a bromeliad), or if you know what a pineapple plant looks like you've definitely seen a bromeliad if you've seen a pineapple plant. These three species are a little bit different in that they don't have pitchers on individual leaves, but instead the pitcher is comprised of a tubelike whorl of multiple broad linear leaves that form a long tube where the prey is captured and digested. It kind of looks like toilet paper roll sticking out of the ground and really it's just a bunch of rolled green leaves. Did you know about this?

Bill: I did not. Now correct me if I'm wrong . . . are all bromeliads air plants? Or no.

Steve: [Hesitantly] Ahhhh . . . when you say air plant, I think maybe a lot of people think that that is going to be a plant that grows on something else, that it really doesn't have roots of its own or nothing significant.

Bill: Right. Oh, that's an epiphyte.

Steve: I think many are epiphytic. But you can still have them growing on the ground, even in the botanical gardens. In Buffalo, we have them just planted in the soil in some spots. And while it's relatively easy to accept that different types of carnivorous plants have independent evolutionary origins, it turns out that these four major groups of pitcher plants are actually not closely related at all.

Bill: So this is all convergent evolution?

Steve: Yes! So even within the pitcher plants, they're not related.

Bill: Whoa.

[Rustling of leaves in the wind briefly grows louder]

Steve: Yeah! So our Western Hemisphere pitchers in the Sarraceniaceae are more closely related to blueberries than they are any other pitcher group. The nepenthes pitcher plants, those guys are much more closely related to sundews and Venus ply traps than any other pitcher plant, which I think is mind blowing, cuz that's a totally different carnivorous plant altogether. But since we really haven't talked about those yet, they're also more closely related to cacti and pokeweed and the pink order than any other pitcher plant.

Bill: What!

Steve: There is a single Australian endemic called *Cephalotus follicularis*, and that one's more closely related to those little wood sorrels – you know, people call them sour grass or I dunno. They're beautiful little plants -

Bill: *Oxalis.*

Steve: Yeah, *Oxalis*, little heart-shaped leaves. But yeah, *Cephalotus* is much more closely related to an *Oxalis* than it is to any other pitcher plant. And then the three bromeliads, this one was easy; they're more closely related to grasses than any other pitcher plant. That last group are the easiest to believe but the other ones I think are mind-blowing.

Bill: It's the frustrating magic of DNA.

Steve: Yeah, right! The pitchers of these groups, even though they look similar, they're really only superficially similar and there are actually a lot of differences. We'll get into it more as we focus on the family that includes our species of interest, the purple pitcher plant. But I think now might be a good time to actually start focusing on the Sarraceniaceae. **Bill:** Well, we have one down at our feet here.

Steve: We do, yes.

Bill: You've put the flowers to sleep, Steve, they're nodding.

[Laughter]

Steve: Yeah, that's something that I'll definitely point out. Why don't we start with the flowers. The flower might be something you notice first. The flower's really these really tall, nodding, globular flower. One of the cool things about it is that if you turn it upside-down, there's kind of like an umbrella-shaped stigma; so the top of the female part of the plant. And if you kind of peel back that umbrella, there's a top of stigmas down there – just a bunch of loaded yellow anthers, just loaded with pollen.

Bill: We'll put some pictures in the episode notes, too, so people can look.

Steve: Yeah, and when I'm not manipulating it like this, it's just kind of drooping down and these dark maroon pedals are just hanging down over that upsidedown umbrella-like female part.

Bill: So this is a tall nodding blossom . . . what would you say, that it's about twelve, eighteen inches tall?

Steve: Yeah.

Bill: And the flower head is probably three, about three inches?

Steve: It's huge.

Bill: Yeah, three to four inches and it looks like it's made out of wax.

Steve: Oh, yeah!

Bill: It doesn't look real!

Steve: Yeah, it's real real funny looking.

Bill: And then the pitchers are growing basally out from the base of that flower stem.

Steve: And one of the interesting things about these type of pitcher plants is that the entire leaf is the pitcher, whereas for example in *Nepenthes*, the pitcher is actually forming at the end of the long stalk that's coming off of the tip of the leaf, and it's really weird. I actually own a *Nepenthes*; it's definitely a really cool thing to look at.

Bill: So now the one we're looking at . . . repeat the name of that again?

Steve: So Sarraceniaceae is the family and *Sarracenia* is the genus.

Bill: Okay. So *Nepenthes*, how big are those compared to this?

Steve: Uhhh, they can be gigantic. But the ones I have are very small. They're like an inch tall right now.

Bill: I was gonna say, "Steve is holding up his fingers."

[Laughter]

Steve: Mine aren't very big but I've seen people who have their own *Nepenthes* pitcher plants and they're gigantic. It's hard to describe how big they are. They're definitely massive, or they can be massive anyway.

Bill: So the pitchers that we're looking at here, I would say these are about (what?) eight inches? The whole pitcher is about eight inches long?

Steve: Yeah, it might not even be that big. I know there are bigger ones out there, but I just want to compare this to *Nepenthes* real quickly. This is something that I kinda just stumbled across online; you're away of the Venus fly trap?

Bill: I've heard of it.

[Chuckles]

Steve: *Nepenthes* have been affectionately called the "penis fly trap" because of how the species actually looks before the pitcher matures and the lid opens up. The resemblance is actually kind of uncanny, veins and all. And you'll never mistake a trumpet pitcher for a *Nepenthes* because they're found on opposite sides of the planet, but I just thought it was really funny that I stumbled across this *Nepenthes* and thought, "This can't be real," so I looked into it and I found it. I guess there's a number that look like that.

Bill: I gotta stop you there cuz I have to share with you some feedback I got on the downy-hairy episode.

Steve: Really!

Bill: From someone who (I'll tell you their name off-mic) but they wanted me to tell you this. They kind of stopped me and said, "Bill, I listened to your downyhairy episode and I had to turn it off." "[Baffled] What . . why?" "I got to the part where Steve made some kind of reference to pounding wood and made some kind of juvenile joke about it? I can't believe you guys went there." He turned it off.

[Laughter]

Steve: He's not our target audience.

Bill: That's kind of what I tried nicely to tell him. Like, I should have said, "I hang around second graders all day."

Steve: So I wanna say, in terms of this one, I could have skipped it but I didn't make it up. This is a real thing that people really do call *Nepenthes* as well.

Bill: Alright.

Steve: So one other thing that you'll notice about the *Sarracenia* pitcher plant; you'll see that it has this single wing that's pointing towards the inside of the plant and just a a single wing down the side of the pitcher. You can compare that to another pitcher plant that I mentioned before, *Cephalotus*, which actually has multiple wings going down the plant. Even though wings aren't a big thing, it's definitely a major difference where as in *Sarracenia*, it looks like someone almost just folded the leaf in half and it's kind of pressed on the one side.

Bill: I was thinking how to describe the leaf, and that's what it looks like. It looks like someone took kind of an oval-shaped leaf and folded it over and glued the edges together, just leaving an opening up at the top.

Steve: And as it turns out, the younger the plant is (the younger the leaf is, I should say), the more the leaf that's made out of that wing (or the greater percentage of the leaf that is gonna be the wing). As the plant gets bigger, a larger and larger percentage ends up being in the trap itself. And the wing tends to decrease in size but looking at this on it's a huge wing on this guy right here.

It really still looks like it's fifty-fifty but this guy looks like it still has a good way to grow.

Jack: Are these always growing and then they go dormant and kind of die off in the fall and then they regrow again to an even larger size?

Steve: Yeah, so *Sarracenia* are definitely perennials so they're gonna keep growing back every year.

Bill: But individual pitcher dies each year, is what you're saying.

Steve: It does, but they're actually continuously replacing each other. The *Sarracenia* leaf, they typically stick around for at least a hundred days but they're really not super, super long lived. You can get pitchers that stick around way longer than that, but they may not be doing much after that point.

Bill: Okay. But they're not evergreen.

Steve: Yes, they're not evergreen, no. Alright, so I just wanna give a general idea of how the Sarraceniaceae is different from the other pitcher plants - just some little difference between the pitchers. But before we go deeper in the family, I just want to quickly mention some points about its evolution. You'll see why we're actually saving the evolution bit for the next episode. So in terms of the evolution of pitcher plants in general, unfortunately there's really little or no fossil evidence to go on. There was a species in China that was found from 125 million years ago that appears to look like our local pitchers from a side profile, but it's unlikely that they're related to the modern pitcher plants because that's actually very close to the appearance of the first angiosperms, so there's no way that it just started of with pitchers.

Bill: No.

Steve: There is actually a hypothesis that these fossil pitchers are not pitchers at all but they might actually be galls created on the leaves of an extinct conifer. There may be little-to-none; there's either something or nothing. In terms of the Sarraceniaceae in general, these guys are known as “trumpet” or “Western Hemisphere” pitcher plants. This family is thirty-three species large; there's three genera, and they're all located within North American and northern South America. To paint a picture, pitchers in this family can be thought of as having four zones. So the first zone is the *lid* or the *hood* that's known as the *operculum*. This area is typically bright colored with extra-floral nectaries for attracting prey, that really mostly attract flying and crawling arthropods. They also have an anti-adhesive surface and downward-pointing hairs for capture. You can actually see it really-really well in the pitcher plants here. They're stiff - **Bill:** Right on the lip of the pitcher.

Steve: Yeah, yeah. The next zone down is this rolled lip, also called the *peristome*. You can actually see it pretty well here; it has this rolled lip on the

edge. This surface is also very slick and actually contains more of those extrafloral nectaries.

Bill: I'm slowly sinking.

Jack: I was gonna say this is one of the best [unintelligible].

Steve: This section has microscopic directional surface features that may make it harder for potential prey to move away from the pitfall trap. This section also contains easily-detachable wax crystals in the inner surface, possibly contaminating the adhesive pads from the pads on insects' feet and generally just coating the prey and making it difficult for them to crawl out. And the third zone into the pitcher is actually more-or-less the danger zone. If you're here, you're as good as dinner. This zone is slippery, hairless, and it's a bit too narrow for the winged insects to escape, especially if their wings are coated in wax. Then the final zone is the pool of rain water and digestive mutualists that exhausted insects fall into. This section also contains dense downward-pointed hairs and that's really kind of adding an extra layer of certainty that the prey just can't escape. As I hinted before, these family of pitchers are within the Ericales order, which makes them pretty closely related to a lot of the other bog-loving species of plants, the heaths – many of which we can actually see around here. I know when I was looking online and even just around us, there's definitely some rhododendron here, some indian pipe [sic], teaberry, cranberry, blueberry, lots of different Ericaceous species.

Bill: Leather leaf. Didn't we use that word *Ericaceous* in the, uhhh . . . Algonquin?

Steve: Yeah, you quizzed me on it, I remember.

Bill: Spruce grouse episode!

Steve: Yeah.

Bill: Yes! Shout-out to the spruce grouse episode.

Steve: But there's also a bunch of non-Ericaceous species as well that we brought up. Again, there's the larch; I know there's black spruce; a number of sedges here; sphagnum; um, and another carnivorous plant, the round-leaf sundew (which we will be seeing as well). Also, when I looked online, there's definitely some bladderworts here as well, and that's in the genus *Utricularia* - totally unrelated to any of these but that would be really great to see. I know they're out here but we might not have the time today to go see one.

Bill: Those were the ones, folks, with the pouches that suck things in. But they need to be in standing water.

Steve: They don't have to be.

Bill: Oh really?

Steve: The ones around here are, but not in general. As I mentioned earlier (and I think this is actually a really interesting point), some carnivorous plants do not release their own digestive enzymes; and all three genera of pitcher plants actually fall into this category. This type of carnivorous is called a holocarnivorous plant, and that's compared with something called a hemi-carnivorous plant, which does produce its own digestive juices. So this means that this group of plants relies on other organisms that live within the pitchers to digest the prey initially.

Bill: It's a mutualism.

Steve: Yeah. And at that point the pitcher can finally absorb the poop of the digestive mutualists.

Bill: [Laughs]

Steve: At first I was actually kind of disappointing that we couldn't spend more time talking about *Nepenthes* because at least four of *Nepenthes* obtain some or all of their nutrients from rat, shrew, and bat poop. So I'm glad we at least got to talk about it. It's still happening; things are still being attracted to these pitchers. They're not mammals but why give them the spotlight, you know. There's a lot of cool things that aren't mammals.

Bill: There's a *True Facts*, it's a great nature YouTube channel about a type of pitcher plant that has evolved to be basically a toilet for a shrew. It produces some kind of attractant to the shrew and in order to get it, the shrew has to position itself over the pitcher.

Steve: Yeah! That's a *Nepenthes* and it's basically a toilet for tree shrews. It's really a fascinating relations. But there's rats, there's shrews, the bats; it's crazy, that group.

Bill: So don't drink that water, folks.

Steve: Yeah, I guess not.

Jack: I could grow some next to my bed.

Bill: There you go! [Laughter] There's your million dollar idea.

Steve: In terms of the family itself, the Sarraceniaceae contains three genera. Starting with *Heliamphora*, these species actually have traps that look a lot like our *Sarracenia* here, but they have a tiny little lid at the top and that's the biggest difference between it and pitchers we have here. All twenty-three species of this genus are endemic to the Guiana Highlands in southern Venezuela, and small portions of Brazil and Guyana, meaning that we probably can't see these pitchers for a while and we have to be content with just knowing that they're there.

Bill: What do you mean you can't see them for a while.

Steve: Well, the U.S. currently has a level four "do not travel" advisory to Venezuela, and that's the highest travel advisory level that the Department of State can give. I don't know much about anything plants, so link to support the International Rescue Committee for the aid of Venezuelan refugees in the episode notes. It has four out of four stars in Charity Navigator so we'll just throw it down there. If anyone feels the need, you can go donate to them cuz they're doing good work, I guess.

Bill: Good job, Steve.

Steve: So on to the second genus These guys are crazy. They're called *Darlingtonia* and it's just comprised of one species, *Darlingtonia californica*. And these guys are found in northern California and southwestern Oregon. This is the sister group to the other two genera – meaning that they branched off evolutionarily earlier and it's actually a bit different. Imagine this tall green and red pitcher, but the top isn't open like the other genera. It's bent over kind of like a cobra head and it has this forked tongue-like lip called a fishtail appendage that is protruding from underneath the head where the pitcher plant opening actually is. And these guys are actually called *cobra lilies*. Have you ever heard of them?

Bill: Nope.

Steve: They're really, really cool. We're actually gonna have to share a picture of them; did you get any picture of what I was trying to describe in your head?

Bill: Sure!

Steve: But they're cooler than I can describe, so we're definitely going to have to share a picture of them at some point. One of the cool things about them is that they have a population that contains a form that is completely in green hues; there's no red whatsoever. It's just this anthocyanin-free form which is really, really cool. Normally you get the reds and the green, but it's just greens. We'll get into that a tiny but later, as well. So *Sarracenia*, finally, the genus that contains the purple pitcher plant - we only have eleven species of them here. This genus is found throughout the southeastern U.S., New England, the Great Lakes states, and much of southern Canada, but the vast majority of its range is due to a single species and actually our target species, *Sarracenia purpurea*. The southeastern U.S. is actually a geographic hotspot for many of the other *Sarracenia* species, but the vast majority of the range is just our purple pitcher plant. Like the cobra lily, there are anthocyanin free forms that are found in nearly every species and they're typically growing with other normally colored individuals. This is cool; through some breeding experiments, that actually seems like the anthocyanin free expressions through *Sarracenia* is likely controlled by just a single locus – so just a single gene with two alleles, the anthocyanin free and just the regular one. The anthocyanin-free one is the

recessive allele there. So I think that's kind of cool that you get both types in many many populations.

Bill: Alright, can we move a little bit because I am really slowly sinking here.

Steve: Yeah, you've been sinking a whole lot.

[Sloshing footsteps]

Bill: [Grunting]

Steve: This looks like a little bit of a path here.

Bill: Well, there's some skunk cabbage nearby. We're walking on the mat and it does feel a little bit like a water bed. Lots of little spruce growing around us, lots of little larch trees. Okay, this is better.

Steve: Hopefully the wind ends up holding up for us here. Alright, in terms of the species within the *Sarracenia* genus, they do a bit of admixture. Natural hybrids have been reported in ever *Sarracenia* except one, and they do so whenever two species overlap. Especially in southern Alabama, northern Florida, and southern Georgia. This is actually a spot where up to five species can cooccur at the same locality; which would be nuts. [Laughing] Imagine if we were at a bog and we're just surrounded by all these different species.

Bill: Yeah, cuz we only have one species here.

Steve: I get jealous of people sometimes when they live in more southern areas anyway. As it turns out (and I find that this is pretty surprising), *Sarracenia* species tend to be pretty infertile, and (strangely enough) hybrids tend to be quite fertile and there have been many instances of backcrossing that have been reported by several authors.

Bill: Many instances of *what*?

Steve: Backcrossing. So hybrids backcrossing with the parent.

Bill: Gotcha.

Steve: It's also important to note here that it remains unknown whether any species of Sarraceniaceae are actually of hybrid origin, but there definitely seems to be some gene flow between the individual *Sarracenia* species, which is kind of interesting. *Sarracenia* species are also self-compatible, so they can just reproduce with themselves; there's nothing really stopping them from doing that. But inbred plants tend to produce significantly fewer seeds, seeds with depressed germination, and shorter pitchers than outcrossed plants. Strangely enough, not all eleven species have the same consequences of inbreeding. I know that there's an individual pitcher plant – the purple pitcher plant – that was introduced to Ohio in 1912, and it grew into a population of 157,000 plants by 1978. That's one plant, so you have to imagine that this population has a very low genetic diversity but it still has dramatic growth nonetheless. In a similar vein, an

introduced Swiss population actually found evidence of outbreeding depression. That meant that there was a greater reduction of seed weight, with increased genetic distance of the parents. Usually it's good to mix things up, but apparently not in this case for the *Sarracenia.*

Bill: No.

Steve: This finding almost seems to corroborate with the purple pitcher plant being the most widespread member of the family but not the most genetically diverse of the genus. Some biologists hypothesize that *Sarracenia purpurea* may have experienced natural selection for inbreeding, but at least personally that's kind of hard to understand.

Bill: What do you mean "natural selection for inbreeding"?

Steve: It's been proposed that there's some protection with inbreeding. Cuz typically when you think of inbreeding in populations, that's gonna decrease your genetic variability, you could have inbreeding depression, and the population can be very susceptible to things like diseases and other things it won't be able to adapt so well. Not all plants are created equal in that regard and we know that inbreeding depression isn't as strong in all populations, but it seems like *Sarracenia purpurea* is really good at inbreeding.

Bill: Okay.

Steve: It's real weird.

Bill: It's an interesting skill.

[Laughter]

Steve: Weird flex, but okay.

Bill: "I'm really good an inbreeding."

Steve: Thinking on that note, it might be a good idea to cut to a Gumleaf ad, cuz we're actually here with Jack and we're gonna record something right out here at the bog.

Bill: Alright! We're here with Jack Butler, the owner of Gumleaf USA. Hello, Jack.

Jack: Hey Bill, Steve.

Steve: Hey!

Bill: Thanks for coming out with us, Jack.

Jack: My great fortune.

[Laughter]

Bill: So Steve and I are standing here right now in our Gumleaf boots. I have on . . . which kind is this?

Jack: Those are the Royal Zip.

Bill: And I've gotta say (I've mentioned it many times in the episodes before), whenever I'm out with these boots, people always compliment me on them. I was out bird banding this morning and someone who is a new volunteer came up and said, "Bill, where'd you get those boots?" I said, "It's funny you should ask!" [Laughter]

Jack: Small world!

Bill: I told them all about Gumleaf USA. And then Steve has on a brand new pair that he just received today, you were kind enough to give to us.

Steve: No one has complimented me on them yet, but it's only because I just got 'em. I will say that we just had to hike over some pretty decent terrain and they were so comfortable; they're really, really good.

Jack: The ones that you're sporting right now are called the Field Boot, and the Field Boots are fabric-lined whereas the Royal Zip and many of our other boots are neoprene-lined. The Field Boot that you're wearing is really intended for (let's say) cool-to-warm temperatures, where the neoprene-lined boots are really designed for cool-to-cold temperatures. But with the Field Boot, you can always just don additional socks if you want to when the weather really gets rough and cold and into the sub-zero temperatures or whatever. So that's always a good option.

Bill: And I can just wear the Royal Zip without socks.

Jack: You can wear 'em without anything; you can wear 'em in shorts if you wanna.

[Laughter]

Bill: Cuz it's pretty warm right now but my feet are alright.

Jack: My Royal Zips are five years old and I find that I wear 'em; I've been out in ten degrees below with just men's cotton dress socks and I was wearing them last week. They're still five years old, they're made of 85% natural rubber so they resist cracking phenomenally well. They're going strong and they're five years old.

Bill: And for someone like me who is very hard on everything he owns, the Vibram soles come in handy.

Jack: Yeah. The other thing I would mention, I guess, real quickly is that from our least expensive boot to our most expensive boot, the soles of the boots are all designed, they're all similar. If I blindfold you, they're all equally as comfortable. You won't know if you were in our most expensive boots or our least expensive boots. The design difference in the boot really comes down to functional differences. Do you want a zipper so they're super easy to get in and out of quickly? Do you have wide calves, whether you're a man or a woman?

Bill: Like Steve.

[Laughter]

Steve: Hey, you've got the zips on.

Jack: So anyway, there's functional differences between them but there's only about five different styles. They're all handmade in Europe and they're all made with a high natural rubber content, which is the reason they're so durable and they resist cracking.

Bill: And for Field Guides listeners, we were just talking about we're going to have a new offer code. If you head on over to the website . . . Jack, what's the website?

Jack: www.gumleafusa.com

Bill: And our offer code is going to be TFG2019, and that'll get you free shipping on your order. Jack, we just wanna say thanks so much for supporting the podcast.

Jack: Really, my pleasure. I'm really honored to be one of your first (and maybe your only) sponsor right now. [Laughter] But I thoroughly enjoy the show. It's fantastic and a number of your listeners have already responded, even from the very first episode that you mentioned our sponsorship on. The phone rang within an hour! It was amazing.

Bill: Wow!

Steve: That's crazy.

Jack: It's really great, so I appreciate it. Thanks, guys.

Bill: Thanks, folks.

Steve: Thank you!

Bill: Alright, Jack, thank you and we'd like to have you on again in the future.

Jack: I'd love to.

Bill: Wow, that was our first ever first-person ad.

Steve: Yeah, we've never done that before.

Bill: I think it went well.

Steve: Yeah. Alright, so now lets talk more specifically about the purple pitcher plant. This species also goes by the *northern pitcher plant*, but it also goes by *Indian dipper*, *huntsman's cap*, *sidesaddle flower*, *Adam's pitcher*, *fever cup*, *smallpox plant*, *dumb-watch*, *whippoorwill boots.* And I hate every single one of these common names.

Bill: What!

Steve: They're all horrible.

Bill: I like Adam's pitcher.

Steve: Nah, it's bad. So as I said before, this is arguable the most successful American pitcher plant -

Bill: Wait wait wait! What was the "dumb" one?

Steve: It was *dumb-watch*.

Bill: Why?

Steve: I don't know. What are those sundials? Maybe it's something like that, I don't know. That was my only guess – the sundial – cuz they're usually in exposed areas on bogs, so . . .

Bill: Oh, like "dumb" like it's silent, you can use it as a sundial?

Steve: I was thinking it doesn't work as a sundial.

Bill: [Laughs]

Steve: I didn't actually look up why it's called that; I was just going to skip it because I hated it so much. [Laughter] Like I was saying, this is arguably the most successful North American pitcher plant, as well as the only member of the genus that inhabits cold, temperate climates. When you're looking at this plant (like I was saying before), the only thing you're seeing is the pitchers. There's nothing else to the leaves. All those leaves are extending from the base of the plant and they're all open at the top, which is pretty convenient for collecting rain. The pitchers on the plant are typically up to six-to-eight inches in height, and this species is actually much more stout than the other pitchers in this genus. The pitchers are green or red-purple with darker red-purple veins. We actually have a really beautiful one, a really great example of that right under us. The opening on top has this large flared-out, frilly lid with nectar glands and conspicuous veins painted right on it. This region also has a coating of fine, downward-pointing hairs, like most pitchers. For this species these hairs are actually longer and thicker than other members of the genus. I also read in one textbook that I was going through that these hairs also produce a numbing secretion as well, so that's going to be something else that helps them catch their prey. The liquid inside (like I was saying) is from precipitation. That harbors mosquito larvae, bacteria, and even tadpoles at times - though that would be incredible if we found on that had tadpoles inside it today cuz it doesn't seem like the water's deep enough. But who knows? Maybe there are some parts of this bog that they could work for. So these species, they actually eat the drowned prey and then they [bleeped] out that sweet, sweet nutrient-rich refuge for the pitcher to chow down on.

Bill: [Laughs]

Steve: Some researchers also think that this open, upward-facing opening of the pitchers are also possibly for catching leaf debris for microbial pre-digestion, and eventually those nutrients will be digested by the pitcher plant itself.

Bill: Wait, wait. So you're saying they eat plants AND animals?

Steve: Yeah! So all that non-animal shmutz in the pitchers may actually just be another source of nutrients in the plant. I remember when I was on the bog a couple weeks ago, I was like, "Eh, this one's just full of junk." It clearly didn't seem like it was full of animal plants at all.

Bill: So you should call them *omnivorous* plants.

Steve: Yeah, I guess so! New category. [Laughter] Digestion of this predigested prey occurs by special cells near the bottom of the pitcher and – strangely enough – individuals that don't flower in a given year (like I was saying earlier) do relatively little digestion, which kind of makes some sense. Why would you waste your energy if you're not needing to put up all that energy into a flower, right? The bottom-most region of the pitcher is this long narrow stalk where the indigestible parts of the insects accumulate.

Bill: Pull up one of those pitchers. We're gonna damage one. You can pour it into Steve's hand.

[Jack laughs]

Steve: Ugh. That's okay.

Bill: Ready? Let's see what's in there. You gotta really tip it all the way over.

Steve: Oh, wow!

Bill: So there's little tiny flying insects in there.

Steve: Also there's bacteria, and . . .

Jack: Shmutz.

Steve: Yeah, shmutz. Even it looks like a little feather or something.

Bill: You can't see the bacteria.

Steve: A couple others. Yeah.

Bill: Can you see any insect larvae wiggling around in there?

Steve: No, I can't see any insect larvae yet.

Bill: It is still pretty early in the season, though.

Steve: Yeah.

Bill: We don't recommend doing that to LOTS of your pitchers if you're out on a bog and you see a bunch.

Steve: You can see that it almost comes to a very fine stem here. This bottom here where it really narrows out, this is the part that would probably collect a lot of the things, like the insect exoskeleton make of chitin that doesn't really digest all the well. That's gonna be something that would likely collect in the bottom here. It doesn't seem like a very active pitcher, but I'm sure we could find some if we looked hard enough.

Bill: But we don't want to pull up many.

Steve: Yeah, right. As a side-note, one Michigan study of 214 forty pitchers found 504 individual insects from 13 orders and 49 families – most of which were flies, but ants were also a frequent victim, as well.

Bill: How many pitchers?

Steve: This was 214.

Bill: And they found about five hundred insects?

Steve: Yep.

Bill: So that's really not that many, if you think about it.

Steve: But it's pretty diverse.

Bill: Sure.

Steve: I think that's kind of demonstrating how they're not specialists with any particular group . . . at least not in every case.

Bill: That we can tell, yeah.

Steve: Yeah, right.

Bill: Maybe they are specialists and the selectively digest the ones they like the best and that's why you don't find them.

[Laughter]

Steve: There are many ways that pitcher plants attract prey, including visual clues [sic], nectar rewards, and olfactory cues. But the *Nepenthes* have another attractant that the *Sarracenia* pitcher plants don't have, and that is acoustic attractants.

Bill: Huh?

Steve: Yeah, I said the same thing when I read that. I was a little bit disappointed but I still think it's a pretty cool thing. It's not that the pitcher plants make noise, but they're the right shape to be an ultrasonic reflector that the bats can use to find them and roost in them.

Bill: Wha?!

Steve: And of course they're pooping in there, so that's where they're getting the nutrition from.

Bill: [Laughs]

Steve: In terms of visual cues, it's unclear if the purple pitcher plant has ultraviolet patterning, but others in the genus do that that. It's also thought that that red-purple patterning is also an attractant, as well. Sometimes these lines are associated with extra-floral nectary production, and this is the phenomenon that's know as the nectivorous lines. Although we haven't found evidence that these nectivorous lines have a significant effect on prey capture, there could be something there. These pitchers also have translucent areas known as aerials or fenestrations, and these are little windows that let in more light than most of the pitcher does. These translucent areas may confuse trapped insects, reducing the probability of their escape OR possibly aid in long-distance attractants in the right lighting.

Bill: There's a hummingbird! Look, see that branch up at the top? There's a hummingbird.

Jack: See that third branch down, fourth branch down?

Bill: Ruby-throated hummingbird.

Jack: Right out around the tip. It's a hummingbird.

Bill: Do you see it?

Steve: I see it.

Jack: [Chuckles] I've never see a hummingbird out in the wild like that. I mean we get hummingbirds around here but I've never seen one perched.

Steve: Nice.

Bill: One of the people that taught me about nature, they said that if you just pick somewhere and stay there for ten minutes, you'll see something worth it. We've been standing here for, well, an hour and twenty-two minutes and we saw mice -

Steve: I guess how often do you see that stuff?

Bill: Yeah. [Laughter] Alright.

Steve: As I was saying, these translucent areas actually confuse the trapped insects, reducing the probability of their escape OR they could as long-distance attractants in the right lighting. They may not be for confusion but there might be something about them that (under the right conditions) makes an insect or something else move closer to it.

Bill: That's a pretty big stretch.

Steve: Maybe if the light's shining on it the right way, they'll see different patterns on it than they would normally see. One thing that I really have to bring up is that it's always important to remember that this red coloring of the pictures might entirely be unrelated to carnivory. Red coloring is usually caused by

anthocyanin production, which is influenced by light, ultraviolet radiation and nutrient availability - meaning that this red coloration predominantly may just play a role in photoprotection or many just being an indication of nutrient stress.

Bill: Well, right, look at the sphagnum at our feet.

Steve: Well, right, you'd think that this is some nutrient stress that they're dealing with right now.

Bill: It's red, and green.

Steve: In terms of nectar rewards, all species of pitcher plants examined to date possess extra-floral nectaries. In the purple pitcher plant, nectar production is particularly high around the peristome – that's that folded-over rim that it has – but plenty of other pitcher plants work like this as well.

Bill: So it's the leaf producing nectar.

Steve: The leaf is producing nectar.

Bill: Wow, that's great.

Steve: The flower does it and the leaf does it.

Bill: That's why they're called extra-floral nectaries.

Steve: Right!

Bill: Outside the flower. See? I got me some college.

[Laughter]

Steve: Other species will have some extra-floral nectaries on the pitcher rim, but also sometimes on the lid as well. But unfortunately, very few studies have actually provided qualitative and quantitative analyses of the sugar or amino acid content in both the floral AND the extra-floral nectaries, which could definitely be different and possibly could allow for different types of specific species attractions for pollinators, prey, or even defenders.

Bill: Maybe I'm wrong but I would think that the pollen in the flower – or the nectar in the flower – would be different cuz you wouldn't want to eat your pollinator, right?

Steve: Right. It's thought that maybe the ones that have the higher amino acid content might be the ones that are for the floral nectaries (not the extra-floral nectaries), but who knows? It could be the opposite for all I know. There's definitely a need; more work needs to be done. In terms of olfactory cues, the traps in all three Sarraceniaceae genera produce sweet-scented nectar -

Bill: I've gotta ask. Now be honest guys; when you first learned about *olfactory*, how long did it take before you realized that it wasn't *old-factory*?

Jack: [Chuckles]

Steve: Oh, yeah, there was definitely a moment in grade school when I was like, "It's *OL-factory?*"

Bill: It was a long time before I realized that.

Steve: I think I even got so confused that at one point when I heard people say *goldfinch* I thought they were saying *goalfinch*. I thought, "It probably just sounds like *goldfinch* but it's really *goalfinch*. That's how confused I was. Apparently I wasn't really reading the name; I was hearing people say the name.

Bill: The best one is our friend Tom from Beaver Meadow Audubon Center, a big birder. He had groups of kids out - [Long screech in the distance] **Bill:** Oh! Redtail.

Steve: Redtail.

Bill: Is it a redtail? Or is it a bluejay mimicking a redtail?

Jack: It's a bluejay.

Steve: That's actually a very good point.

Jack: I saw it over here earlier. It's a bluejay.

Bill: Could be a bluejay. But the kid on Tom's walk -

[Bird call]

Bill: yep, there it is.

[Repeated birdcalls]

Bill: [Chuckles] Laughing at us. He pointed out to Tom on a tree nearby there was a new-*thatch*.

Steve: Oh, no. *Nuthatch, new-thatch.*

Bill: A *new-thatch*. [Laughter] I kinda like that better. Alright! Sorry, Steve.

[Multiple birds calling]

Steve: So *Sarracenia purpurea* tends to have weaker scents that the others species of the genus and they tend to produce fewer components than are typically produced by photosynthetic leaves. It also seems like *Sarracenia purpurea* changes its leaf odor composition over time. It could be the case that the young pitchers target flower-visiting insects by producing its own volatiles, and then older pitchers just rely on dimethyl disulfate created by decaying prey to attract carrion feeder for capture.

Bill: Oh, that makes sense.

Steve: They're kind *prey-switching.* This *prey-switching* phenomenon is actually also seen in *Nepenthes* as well. A final aspect that needs to be considered is a cost-benefit analysis of producing scents in the first place - how much reduction

and growth under reproduction will result from re-allocating its resources towards this scent that it's producing. If the growth and reproduction in these plants are limited by nitrogen and phosphorous as it is in most carnivorous plants, then the production of compounds containing only carbon and hydrogen and oxygen (such as terpenoids, anthocyanins and nectars that don't contain amino acids) would have little negative impact on the growth and reproduction of the plant. That just means that these compounds that have a very low cost to the plant, that could be easily offset by the benefits in enhanced prey capture. There are many questions that still need to be answered, but for now we need to be careful of the claims that we make about prey-attraction because there really needs to be a lot more work done in this group. Alright, so another interesting bit that involves a term that we've actually heard before from Bill – *inquilines*. Bill did bring this up in our first episode on goldenrod galls.

Bill: I completely do not remember.

Steve: These are species that exploit the living space of another species.

Bill: Oh yeah, I remember.

Steve: An example would be a goldenrod gall, hence the name of the episode. These groups have actually been studied best in *Sarracenia purpurea* and that's pretty lucky because that's what I'm trying to focus on here. The purple pitcher plant might be a good candidate for this because more than any other member of the genus, the purple pitcher plant has relatively prostrate growth form. Also, the pitcher mouth is open to precipitation, making it consistently full with liquid, and the stout shape of the pitcher decreased desiccation, providing a reliable microenvironment for other species to live. Individual leaves are generally colonized within just days of opening, but they typically stick around for at least a year and some have actually been found to continue digesting up to two years after opening.

Bill: Wow! They take their time.

Steve: The purple pitcher plant inquiline community has become a model experimental system for studying contemporary questions about biogeography, community ecology, and evolution. But just for the purposes of what I'm talking about today, I just want to briefly describe a few species that spend a significant portion of their lives in and around pitcher plants, most of which contribute to the digestion of prey within the pitcher. Now I'm gonna backtrack ever so slightly. I mentioned earlier that the Sarraceniaceae pitchers don't produce digestive enzymes, but (at least young purple pitcher plants) they do have digestive glands. This is gonna sound weird but their role in digestion still requires some exploration because clearly there's a whole lot of stuff that lives inside the pitchers that are not being digested. There's been enough evidence that we know they're producing digestive enzymes but it doesn't seem like they're doing anything. So for all intents and - **Bill:** Just in the young ones.

Steve: Yes. But the old ones don't have it. It seems like even though they're producing it, they're effectively a species that doesn't product their own digestive enzymes. These inquilines include microbes like protobacteria and bacteria, and a variety of yeasts. There's also protists and rotifers that are also present; they feed on these microbes. The microorganisms themselves are prey to at least a few species of carnivorous mosquitos and midges that complete their life cycle within the pitchers, and actually many species of flesh fly larvae are also common in pitcher plants; these guys are also feeding on the prey captured inside the leaf. This group is sort of interesting cuz they also partake in cannibalism and, due to this cannibalism, it often results in one survivor per leaf in some species.

Bill: A pitcher plant death match.

Steve: Yeah, right! But the pitcher plant seems life it's getting a whole lot out of it.

Bill: Purple pitcher plants also have non-aquatic inquilines, including four moth species that are actually obligate herbivores on the pitchers. So they eat the inside and they just leave this thin, membranous outer wall and then they generally weave this fine web over the top of the pitcher, likely to protect themselves from predators. And then the larvae can actually move from leaf to leaf but then eventually they're move to a final leaf where they'll cut a hole in the bottom of the pitcher, draining it out so they don't drown, and that's when they'll actually develop into a pupa. [Chirping bird] They'll actually do that part of the life cycle inside the pitcher. And finally, multiple spiders are actually prey, competitors, or even mutualists of the purple pitcher plant. Finally, I want to briefly focus in on the status – the current status of the purple pitcher plants. By 2009, wetland area in the USA had fallen to about 50% of that present in the 1600s and habitat loss is definitely the largest threat to carnivorous plants in North America cuz they're not money makers. You know, a parking lot does a lot better than pitcher plants. [Laughter] Unfortunately. Although pitcher plants are found worldwide and several species have large geographic ranges, all of them occupy patchy restricted microhabitats within their geographic ranges. Dispersal limitation may actually be one of the most important variables, but transplants have been successful in many species. Even though they can't get far themselves, we can transplant many of them and there is some plans, some strategies for conservation of vulnerable carnivorous plants. But again, we'll just talk about that in some future episodes because there's actually a lot of interesting stuff that they're doing. When averaged within genera, only sundewlike (but they're totally unrelated carnivorous plant genus) *Byblis* as well as *Nepenthes* and *Sarracenia* were projected to have more increases than losses in habitat suitability in regions where they're already located – meaning that as climate change continues, they'll basically continue to persist in and around their current habitat. So even though things seem like they're good, it's not like they're expanding all that much. But that's three groups out of a much larger

group of carnivorous plants. That's very very little that are going to be benefitting.

Bill: Or at least doing okay.

Steve: Yeah. So even though carnivorous plants . . . it's not looking that good for the future, at least the purple pitcher plant might be doing alright.

Bill: Yay!

Steve: Woohoo! Kind of a high note. That's it for purple pitcher plants, though I do plan on covering a couple other carnivorous plants before the summer is over and really expand our knowledge of the carnivorous syndrome. Carnivorous plants are not a self-contained topic so as we build our understanding of carnivorous plants, we simultaneously gain insights into non-carnivorous plants, as well. There's actually a lot of research that still needs to be done, and in order to better understand evolution in general, further research need to be focused on both carnivorous and non-carnivorous plants together. If you live in an area with carnivorous plants or live close enough by an area with carnivorous plants, I definitely recommend going out to look for them but – as always – if you do, be respectful of the habitat. These are fragile environments so please walk only on existing trails and don't poach any plants, cuz there's a lot of cool ones out here. Don't touch them.

Bill: We just pulled off a leaf.

Steve: Yeah. [Laughter] It's like plucking a black cherry leaf off. It was nothing. Alright guys, I hope you enjoyed the episode -

Bill: First and foremost, we would like to thank our growing list of Patreon supporters. So thank you Eliza, John Weaver, and Nick and Rebec. We're thankful for every single patron but at the end of every show we give a special thanks to our top patrons. So thank you Rob, WeNamedTheDogIndie, Dean, Christina, Gavin, Polliwog, Jacqueline, Jessica, and especially Ken, Diane, Morgan, Elizabeth, Daniel, Susan, Rachel, Orange Julian, and Alyssa. Thank you folks, so much. And we also want to thank our new five-star reviewers on iTunes; so thank you CKbones33, bethabe, ElectroZman, and Rangers Almanac. And our two reviewers on PodBean - Rich Monroe Monroe and the Drunk Phytologist. I gotta say, the Rangers Almanac, I like how he said he likes our dad humor.

[Laughter]

Steve: Yeah. I mean, that's a good way to put it, I guess. And because of my personal shortcomings, this episode may or may not have a thumbnail by Always Wandering Art, but as always links to their website and Etsy page in the episode notes. I also want to give a few mentions to websites that have mentioned us recently. So thank you to Ungardening, Concord Wildlife Alliance, All Outdoors Guide, London Peregrine Partnership, An incomplete list of podcasts about the natural world, and Flying South Birder. Thanks you guys, so much.

Bill: I haven't checked those out yet. As we said before, please go check out GumleafUSA.com. We have links in the episode notes and on our website. If any of you have your own questions, comments, or episode suggestions, send us an email at TheFieldGuides@gmail.com. You can always visit our website at TheFieldGuidesPodcast.com and all our social media links are there. If you like what you hear and would like to support the podcast, you can do so on Patreon.com/TheFieldGuides or through the PayPal donate button on our website.

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Bill: See you next month!

Jack: Bye!