

Erin Welsh	"What a night have I passed, not being able to get to sleep from animals crawling continually all over my poor dear person. If once I had got to sleep, I would then have defied them but it was not practicable. But what were these animals? Why to know that, I looked this morning at the bed's head and behold I saw some hundreds of bugs on their march home, full of prey I dare say. Though bugs do not like me in general, I suppose an overabundance of population had created a famine for I was bit in three different places, all three on a very tender part which I shall forbear mentioning and which we Britons think is the best part of a bullock to make a steak of. At 5 this morning I left Capua, glad to get out of such a dirty hole. However I deserved it for going to bed last night without looking. Whereas had I proceeded in my customary manner, laying myself down on a board, bench, or table, I should have slept like a hero. But Naples had made me luxurious and this night was I repaid for it."
Erin Allmann Updyke	"I slept mercifully, not well but some. On looking however at my fair hand in the morning as it lay outside the bedclothes, I perceived it to be all, what shall I say? Elevated into inequalities, significant of much. My pretty neck too, especially the part of it Babbie used to like to kiss was all bitten infamously. I went this morning while a man was taking down my bedstead to look for the bugs which were worse last night of course, having found what a rare creature they had got to eat. And investigated another lodging in a beautiful little garden, villa-wise, rejoicing in the characteristic name of Flora Cottage. God knows whether there'll be bugs in it. And now dear, if you think my letter hardly worth the reading, remember that I am all bug bitten and bedeviled."
TPWKY	(This Podcast Will Kill You intro theme)
Erin Allmann Updyke	I love these old timey letters about their woes. You know?
Erin Welsh	I mean it's funny because I think the language style that it's written in seems so quaint from now that it kind of glosses over the horrors that they're experiencing.
Erin Allmann Updyke	Yeah, it makes it sound like what? But then you're like oh, you're being destroyed by bugs? Great. While you sleep.
Erin Welsh	While you sleep. Yep. But bug bitten and bedeviled is genuinely I think my favorite phrase that I came across and there are so many contenders. But it's just so good. It's just so good. Well I found both of those quotes from a paper that is just chock full of old quotes about bed bugs called 'The Bed-Bug and the Age of Elegance'.
Erin Allmann Updyke	Ooh.
Erin Welsh	The first one was by Lord Herbert from September 1779.
Erin Allmann Updyke	Okay.
Erin Welsh	And the second was by Jane Welsh Carlyle, no relation as far as I'm aware, from 1843. And she had so many letters about bed bugs. An incredible number.
Erin Allmann Updyke	Wow.
Erin Welsh	Yeah.
Erin Allmann Updyke	Poor lady.

Erin Welsh: I know, right? Hi, I'm Erin Welsh.

Erin Allmann Updyke: And I'm Erin Allmann Updyke.

Erin Welsh: And this is This Podcast Will kill You.

Erin Allmann Updyke: Today we're talking about bed bugs.

Erin Welsh: We are. I'm so excited, Erin.

Erin Allmann Updyke: Me too. It's going to be fun.

Erin Welsh: They're horrible little creatures in the way that they invade your life and make you miserable, make you have to throw out things and whatever. But also they're so fascinating. They're really cool.

Erin Allmann Updyke: They're cool little bugs.

Erin Welsh: And I can't wait to talk about them more and learn about them more. But first-

Erin Allmann Updyke: It's quarantini time!

Erin Welsh: It is. What are we drinking this week?

Erin Allmann Updyke: We're drinking Sleep Tight.

Erin Welsh: Yeah. I mean for those of you that may not know that that's a phrase, I feel like it's a pretty common saying to hear.

Erin Allmann Updyke: Yeah. Sleep tight and don't let the bedbugs bite.

Erin Welsh: Yeah. What is in Sleep Tight, Erin?

Erin Allmann Updyke: It's a delicious little concoction with gin and blackberries, lime juice, pomegranate juice, top it with a little tonic water. Fantastic.

Erin Welsh: It really is.

Erin Allmann Updyke: We'll post the full recipe for the quarantini as well as the non alcoholic placeborita on our website thispodcastwillkillyou.com and our social media channels.

Erin Welsh: We certainly will. On our website you can find the usual things that you can find on our website, transcripts, links to Goodreads list and our bookshop.org affiliate account, links to music by Bloodmobile, links to the sources for all of our episodes. There's more there, merch, Patreon, transcripts. Did I already say transcripts? I think I did. I think that means it's time for us to move on to the content now. Unless we have any other business.

Erin Allmann Updyke: No other business, Erin.

Erin Welsh	Okay.
Erin Allmann Updyke	Let's get into it, shall we?
Erin Welsh	Let's do it. Right after this break.
TPWKY	(transition theme)
Erin Allmann Updyke	So this is technically jumping ahead all the way to the current status just a little bit but I really like this quote. And I just feel like it gives so much context for why this bed bug story is just so good. So I'm gonna start with it. Okay, ready?
Erin Welsh	Okay.
Erin Allmann Updyke	So this is from a 2012 paper titled 'Bed bugs: clinical relevance and control options'. "Not only was the reappearance of this pest unexpected but the degree of the resurgence has almost been met with awe by many in the pest management industry." Awe.
Erin Welsh	Awe. But it's the unexpected part that gets me because-
Erin Allmann Updyke	I know.
Erin Welsh	Was it really unexpected?
Erin Allmann Updyke	Was it? We'll get there eventually.
Erin Welsh	Okay.
Erin Allmann Updyke	But first let's talk about bed bugs, shall we?
Erin Welsh	Yeah, I think that's why we're here.
Erin Allmann Updyke	That's why we're here. We're going to talk about what these bugs even are, what they do to us, and that's it. That's all I'm going to talk about. And then we'll hear from you. Okay.
Erin Welsh	It's a good start.
Erin Allmann Updyke	Thanks. So bed bugs are obviously bugs, they're insects. They're in the family Cimicidae, in the order Hemiptera, which are in fact true bugs. So you're allowed to call them bugs.
Erin Welsh	True bugs.

Erin Allmann Updyke

We have talked about true bugs on this podcast before in our Chagas disease episode. So bed bugs are in the same order but are very different bugs than kissing bugs, which are what spread Chagas disease. However like kissing bugs, Cimicids or bed bugs are also hematophagous or blood feeding insects. Bed bugs are flightless, they're kind of little like oval-shaped, very small, like 1-3 millimeters. And they are incredibly flat, like amazingly flat bodied. Both the males and the females have to bloodfeed on vertebrates in order to survive. And there are at least 90-ish, maybe more, species of Cimicids but only a handful tend to feed on humans. And the two that most commonly and most preferentially feed on humans and therefore are the most important for us as humans are the common bed bug, *Cimex lectularius* and the tropical bed bug, *Cimex hemipterus*. So those are the two that I'm going to focus on entirely. So whenever I talk about bed bugs, I'm talking about those two species, the common and the tropical bed bug. But there are so many more.

Erin Welsh

So many more.

Erin Allmann Updyke

And like our friends the kissing bugs that we talked about in the Chagas disease episode, these insects feed on blood throughout all of their life stages. They don't metamorphosize like a lot of insects we know and love and talk about on this podcast more often like flies or mosquitoes or even ants and beetles and things. But instead what bed bugs and all true bugs do is they go through nymphal instars and bed bugs have to bloodfeed at each one of these stages in order to grow into the next instar.

Erin Welsh

How many stages are there?

Erin Allmann Updyke

In general, five nymph instars. So they have to feed at each one of those and then the females have to feed every time in order to make eggs as well. So they have to continually feed to be able to continue making eggs.

Erin Welsh

And how often do they need to feed?

Erin Allmann Updyke

Great question. In general they feed every few days or so, maybe every 3-7 days. However they can survive for very long periods of time and exactly how long depends on what paper you read and of course the environmental conditions and everything, but we're talking potentially months without blood feeding. And they can just hang out and survive.

Erin Welsh

Yep.

Erin Allmann Updyke

You have that, right? So those two species, *Cimex lectularius* and *Cimex hemipterus*, the common and the tropical bed bug prefer human hosts but they're not terribly picky. So they'll also feed on our pets and other domestic animals, even birds, that can cause a lot of damage to poultry flocks, etc. But in general bed bugs tend to be attracted to their hosts, both by the carbon dioxide that we breathe out as well as our body heat and then a whole bunch of other potential chemicals and kairomones that we give off that they can detect. And I don't know what these are and I knew you might want to ask. But they can detect a really wide variety of chemicals. So we're potentially emitting a bunch of different little things while we sleep that they're attracted to.

Erin Welsh

Ugh.

Erin Allmann Updyke

Bed bugs are, you would think, like the least impressive movement-wise. They can't fly, they can't jump, they just walk.

Erin Welsh

They can scuttle.

Erin Allmann Updyke	They can scuttle.
Erin Welsh	Very fast.
Erin Allmann Updyke	They are very fast and they can walk a surprisingly long distance for how incredibly tiny they are. And so the way that they generally live their life is that like I mentioned they feed just every few days and then once they have a nice big blood meal, they scuttle off and they go and rest and they lie dormant while they digest that blood meal. And because they do not live on us like fleas or lice, they generally are found on our bedding or chairs or upholstery where they can hide during the day and come out only at night to feed. These bugs are photophobic which is part of why they like a nighttime snack and their peak feeding tends to be between 1 AM and 5 AM, which also happens to be when we tend to sleep the most deeply. I just love it.
Erin Welsh	I know. I mean you have to admire it.
Erin Allmann Updyke	You have to. How can you not?
Erin Welsh	Oh my goodness.
Erin Allmann Updyke	Then once they've had their fill, they crawl or scuttle on back to their nests which are called refugia.
Erin Welsh	I mean that's kind of cute.
Erin Allmann Updyke	Isn't it? I love it. And they do aggregate there because they release a whole bunch of pheromones for each other to help them find these little nests, these little refugia, which also I read helps them with water conservation. Love that for them.
Erin Welsh	That is amazing.
Erin Allmann Updyke	Having a whole bunch of them all together rather than living all alone.
Erin Welsh	Yeah.
Erin Allmann Updyke	And in addition to having these aggregation pheromones, bed bugs also have alarm pheromones. So if you find their little abodes and then you start killing them and it smells really bad or weird or some descriptions say sickly sweet, that is the alarm pheromones that these bed bugs are releasing to warn any other little nests or refugia, scuttle away, scuttle away, they found us!
Erin Welsh	That is so interesting because I came across several quotes describing how horrible they smelled or how distinctive they smelled. And it never occurred to me to wonder why they smelled.
Erin Allmann Updyke	Yeah. And in general, at least from what it seems is a lot of that smell, it's possible that maybe some of it is those aggregation pheromones that we're smelling, if it's just there all the time. But I think a lot of it most of the time is in the context of them releasing alarm pheromones. So we found their nest and now they're releasing all these pheromones and now you smell it for the first time.

Erin Welsh

That is incredible.

Erin Allmann Updyke

I know. The other way that you can find their little nests is poop. Their poop. Fecal spotting, so little black little dots in the corners and crevices of mattresses or bed frames or walls. Those are usually one of the first signs or indications of a bed bug infestation. Rather than finding the bugs themselves, it's usually fecal spotting first and then you have to look really hard to find the bugs. Female bed bugs, I tried to get a handle on just how many eggs they lay because it seems very important when we're looking at bed bug infestations because they are impressively good at spreading. And yet I was not all that impressed with how many eggs an individual female can lay. One of the papers that I read said that they lay 5-8 eggs a week, adult females, for 18 weeks.

Erin Welsh

That's surprisingly low.

Erin Allmann Updyke

Right. And per Erin math, that's only like 92-144 eggs which is not that much. But then other papers suggested it's more like 200-500 eggs in a lifetime, which is more.

Erin Welsh

Okay.

Erin Allmann Updyke

But still not as much as I expect for an insect that can spread as rapidly as we know that it can.

Erin Welsh

I wonder because when we think of insects, we think of them laying or arthropods laying tons and tons of eggs sort of like in a hedging strategy, right? 10% of them survive to be larva, 10% of them survived to be nymphs, etc.

Erin Allmann Updyke

Right.

Erin Welsh

So what is the instar survival rate or mortality rate for bed bugs? Do they survive better because there are fewer? What is maternal care like? I have so many questions now.

Erin Allmann Updyke

I have those same questions. I don't have answers for them. But yeah, it's a really good question. You would think maybe it is quite a lot higher because they live in these little refugia, right. So maybe because they're living in such close association with hosts, maybe they have a better chance at survival, maybe, etc, etc.

Erin Welsh

Yeah.

Erin Allmann Updyke

I don't know.

Erin Welsh

Yeah.

Erin Allmann Updyke

It was an interesting number. So a few hundred eggs. And yet-

Erin Welsh

And yet.

Erin Allmann Updyke

Just wait. And for those of you who wonder how long are they biting me for? An adult tends to take about 10-20 minutes to become fully engorged. So they're biting you every couple of days, 10-20 minutes at a time, etc. Hundreds of bugs laying hundreds of eggs. Okay?

Erin Welsh

Yeah.

Erin Allmann Updyke

Love that. There was also I will say in the bed bug literature, aside from the human clinical side of things which is what I'm about to get into a little bit more, there is a lot of very interesting stuff in the literature about what I guess is one of the other very interesting parts of bed bug biology and that is that the way that they mate, which is very different than most bugs. And this is that the males pierce the female's abdominal wall in order to inseminate them, not the genital tract directly. This process is called traumatic insemination because it's literally causing direct trauma to the abdominal wall of the female.

Erin Welsh

Two questions.

Erin Allmann Updyke

Okay.

Erin Welsh

Is traumatic insemination common across all bed bug species? And the second question is what consequences does this have besides insemination?

Erin Allmann Updyke

Great questions. So whether all species of bed bugs do this, I don't actually know because I really only read about these two species. But I'm pretty sure that this is common across Cimicids in general.

Erin Welsh

Okay, okay.

Erin Allmann Updyke

Yeah. Now what consequences does this have? Kind of a lot. And in fact it has been shown that this process can actually reduce survival in the females which is fascinating. It has also led to the evolution of an entirely new paragenital tract which is still though not actually used for insemination, it's generally still the abdominal wall, but it has led to really strong sexual selection in various ways.

Erin Welsh

Like what?

Erin Allmann Updyke

I didn't dive deep into anything beyond that because there's simply too much other ground to cover.

Erin Welsh

How on earth did this evolve?

Erin Allmann Updyke

Erin, I don't know the answer to that.

Erin Welsh

Well and also so the genital tract is used for depositing eggs?

Erin Allmann Updyke

Right. Yeah. So that's still how eggs are going to be laid is through the genital tract.

Erin Welsh

Right.

Erin Allmann Updyke

But it's not how insemination occurs.

Erin Welsh

Wow. Okay.

Erin Allmann Updyke

Yeah.

Erin Welsh

I mean I knew that but it's just still mind blowing.

Erin Allmann Updyke

I know. And it's really weird.

Erin Welsh

Yeah.

Erin Allmann Updyke

Especially that it can reduce survival. Anyways, that's all I've got. I've got papers, you can read more. People can get really into this and maybe we'll get some cool fun answers out of it. Let's move on to what we tend to focus on on this podcast, which is like what happens to us humans.

Erin Welsh

Yeah but what about humans?

Erin Allmann Updyke

What about us? When we get bitten by these bugs, no doubt the most common thing that anyone is going to get from a bed bug bite is localized skin reactions, meaning we're itchy. So sorry in advance, everyone's gonna be itching for the rest of the time that I'm talking if you're not already. So how does this process of feeding actually work and why do we get so itchy from it? Like pretty much all Hemiptera, bed bugs have these mouth parts that are made specifically for piercing and sucking. Other Hemiptera use this type of mouth part for piercing plants and sucking out their sap or for piercing the exoskeleton of other bugs and sucking out their guts. Bed bugs use them for piercing our skin and sucking out our blood.

Erin Allmann Updyke

So they have these very fine little needle mouths, they stick them into us, they inject into us their own saliva which contains a whole bunch of proteins, many of which contain anticoagulant properties which makes sense. Some of these proteins help with vasodilation so that they get more localized blood flow to the area. Some of them inhibit platelet aggregation and activation which is the first step of our clotting cascade, see our hemophilia episode for details. Some of them actually inhibit factor 10 which is fascinating, which is another part of our clotting cascade, in order to just further delay blood clot formation. It's really impressive stuff. It's unclear if anything that they inject serves to anesthetize our skin.

Erin Allmann Updyke

But these are teeny, teeny, teeny, tiny little needle mouths. So even if it doesn't, it's unlikely in general that we probably feel this because of just how small those needles are. Then they suck up blood, withdraw their little needle, and crawl back to their refuge. What you may see after the fact right away are maybe little pinpoint flecks of blood on our sheets. But very often you won't see any evidence that you got bitten by bed bugs overnight until your skin reacts to it at a future point. Now one big question is how long does it take to have a reaction to bed bug bites? And that is not as easy of a question to answer as you might think. A lot of the literature says that it might take many days, like several days, but it really depends person to person as I'll get into, like what each person's specific reaction might be. And in some people it's very possible to have a reaction within 24-48 hours.

Erin Welsh

Okay.

Erin Allmann Updyke

So it's not very clear cut if bites for example appear on your body, when exactly the bites actually occurred. That make sense?

Erin Welsh

Yeah. So like if you just came back from a trip and a week later you're like I have bites, are they from the last hotel I stayed in or whatever?

Erin Allmann Updyke

Right. Or are they from last night?

Erin Welsh

Or did I bring them back from the hotel that I stayed in and now they're with me?

Erin Allmann Updyke

Exactly.

Erin Welsh

Are there certain parts of you that bed bugs like to bite?

Erin Allmann Updyke

Let's get into it, shall we?

Erin Welsh

Yes.

Erin Allmann Updyke

So let's talk about what it looks like, where you find them, etc. If someone is going to have a reaction to these bed bug bites, which not everyone does, what you usually see initially are little, and by little I mean like 2-5 millimeters, so pretty small, flat red spots. And yes, it is slightly more common, Erin, that you might see these spots on your arms or your legs or your neck or your face. This is not for any other real reason other than clothing can really help protect against bites. So arms, legs, neck, face, these are the places that are most likely uncovered in bed. Anywhere that's uncovered can potentially get bitten. These little flat red spots can then progress over time to these round or kind of oval-shaped wheals, kind of like hivey looking like slightly raised bumps.

Erin Welsh

Yep, yep.

Erin Allmann Updyke

Though they're not true hives but they kind of can look a lot like hives. They can actually enlarge quite a bit. So now instead of looking at little 2-5 millimeter dots, you might have 2-6 centimeter wheals and they can be really, really itchy. And if you have a whole bunch of these bites then these individual wheels can kind of coalesce into what looks like a more widespread rash and the more that you scratch at it, the more that it can exacerbate this trauma and not only spread what looks like the rash and the itching, but also can make it harder to see what's really going on underneath on the skin itself because of all this scratching.

Erin Welsh

And with repeated exposures, do you get more sensitive to bed bug bites?

Erin Allmann Updyke

Yeah. Yeah, exactly. So I'll get into it a little bit more later but the truth is that we don't understand the pathophysiology of this response. Like why do some people have really severe reactions to bed bug bites and other people might be living with bed bugs for months and never even really know, right? It's very, very rare but sometimes people can have even more severe reactions where they end up with systemic symptoms, like fevers and feeling really cruddy from how many bug bites they've gotten. And we don't really understand this reaction itself but there is some evidence at least that it's maybe in part like an allergic response where we have an elevation in IGE which mediates a lot of our allergic responses and our hypersensitivity reactions. So yes, there is data, though the studies are not great, that suggest that with recurrent exposure you're more and more likely to have a reaction of some kind. So studies suggest that if you give someone enough bites, eventually almost everyone will develop some kind of a reaction to bed bug bites. But with a single exposure, maybe less than 50% of people will have any kind of a reaction at all.

Erin Welsh

Okay.

Erin Allmann Updyke

And like I mentioned, even the time frame of how soon after a bite you might develop that reaction is a little bit unclear. So if it's a very severe reaction, then maybe within 24-48 hours you might see the initial little red dots that then progress over a number of hours or a couple of days. But if someone has only been bitten a couple of times in their life, then maybe it is a few days before you notice anything. But it all kind of depends on not only how many exposures someone has had but how sensitive they are, maybe how much of a hypersensitivity reaction they have at baseline, etc, etc. Often in the literature bed bug bites are described as being linear, so like all in a little line along your arm or along your leg.

Erin Welsh

So they feed and then they move and they feed and then they move and then they feed?

Erin Allmann Updyke

I love this question. Almost certainly no.

Erin Welsh

Okay.

Erin Allmann Updyke

And I'll link to a paper that proposed several different possible hypotheses as to why we sometimes see these linear bites like all in a little line or a lot of times they're described as in groups of three, which is called breakfast, lunch, and dinner.

Erin Welsh

Oh my god, that's really cute.

Erin Allmann Updyke

Isn't it? It's horrific, thank you.

Erin Welsh

It's horrible.

Erin Allmann Updyke

But yeah, one of the proposed hypotheses was oh are they biting and then maybe getting disturbed, so then they have to move a little ways and then biting again? But no, the best hypothesis that I saw for this is that it's most likely groups or bunches of bed bugs that are all kind of lining up and biting you all at once.

Erin Welsh

Oh my gosh, buffet style.

Erin Allmann Updyke

Buffet style. Especially because when bed bugs feed, remember that they're hiding say in the corner of your mattress all day, right, then you lay down for bed in your tank top with your shoulder exposed, you're sleeping on your back, so your shoulder is pushed up against your mattress. And these bed bugs crawl out from underneath the underside of your mattress in the corner and they crawl up and your shoulder is in contact with the bedding. These bugs like to maintain contact with the bedding during feeding. So they're going to all kind of line up in a place that's easy for them to reach and just bite, bite, bite you all the way along. And so that's one of I think the kind of best hypotheses is that you have groups of bed bugs, remember they're secreting aggregation pheromones, they're telling their friends hey, I found a great spot. So everyone's coming up, they're having a buffet where they can have close contact to the bedding so they can hop off when they need to, not literally hop but just release and then crawl away. And that's most likely why we see sometimes these linear patterns. But it's often also that there is no pattern whatsoever to these bites, there's just a bunch of bites everywhere.

Erin Welsh

It's so interesting because I feel like competition within a species is often such a strong driver of behavior of certain adaptations of everything. But with bed bugs it seems like teamwork has been decided upon as the answer, the solution.

Erin Allmann Updyke

Teamwork makes the dream work.

Erin Welsh

Yeah.

Erin Allmann Updyke

I mean that's just a hypothesis. I don't know that we have a lot of data to say that that's definitely what's happening here. But the last kind of reaction that some people can also have is again in more severe cases you can end up with kind of a blistering rash, more like bloody blisters or just like fluid-filled blisters, again if you're having a really, really severe reaction. In truth, bed bug bites are very difficult to distinguish from really any other bug bite. And you really have to find the bugs themselves to be sure that what you're dealing with is actually bed bug bites and not other bug bites or scabies, which is very commonly confused with bed bugs, or allergies to something else like the new laundry detergent that you switched to because this could look a lot like an allergic reaction, or a staph infection, although bites like this could get superimposed with things like a staph infection. So it is difficult to diagnose bed bug bites.

Erin Welsh

Is it not common then to ever feel the bed bugs bite? Because I feel like our firsthand accounts were very much like I am feeling them, they're crawling all over me. That's certainly what I read in doing research.

Erin Allmann Updyke

It's a good question. In general, these bugs are tending to bite when we are asleep and generally not coming out until people are probably quite asleep. Now insomnia or sleep disturbance is very common in bed bug infestations. This can sometimes be caused by the actual like itch scratch cycle where you've had so many bites that you're itchy, so you get awoken by this itching. Then you wake up, you scratch it, that exacerbates the reaction so you can't get back to sleep. So then if those bed bugs are there, are you feeling the bed bugs or do you just know that you have had bed bugs or you think that you have bed bugs, so you're feeling things that are itching? But it's hard to know is that really the bugs or is it not? I don't think that it's impossible to feel these bugs, they are again like 1-3 millimeters so they're definitely visible and you could potentially feel them. But in general, they're biting when we are asleep asleep. So you're probably not really feeling them.

Erin Welsh

Okay.

Erin Allmann Updyke

Which is again why it can be so hard. And then who knows how long after you've been bitten you have a reaction to it, you have a visible mark from it. So that's like most of bed bugs.

Erin Welsh

I'm going to take us back to the beginning.

Erin Allmann Updyke

Okay.

Erin Welsh

Where you said that bed bugs can crawl, scuttle, a surprisingly long distance. What is that distance?

Erin Allmann Updyke

One paper that I read said up to 100 ft. I don't know how common that is but definitely like numbers of feet, like they can go from say like the corner of your room up onto your bed and then onto you. Yeah, your face says it all.

Erin Welsh

I mean yeah.

Erin Allmann Updyke

In general though, they're not probably crawling all around your house unless they have to if you're not like sleeping in the same spot every night. The way that they tend to be distributed longer distance-wise is they will take up residence in your luggage, in your sheets, and be moved from room to room say in a hotel for example, they will be on furniture or pillows, things that get moved around room to room, apartment to apartment, ship to ship on a cruise ship.

Erin Welsh

Okay, so let's talk about some of the things that affect their longevity in these environments. I know that adult bugs can live for a very long time without having a blood meal. But I'm assuming that like many other arthropods that feed on blood, they're affected by humidity and temperature primarily?

Erin Allmann Updyke

Yeah.

Erin Welsh

Okay.

Erin Allmann Updyke

Definitely. So humidity, temperature, environmental conditions will affect not only how long they live in general but also how long it takes for them to hatch and then develop into adults. But the other thing to know is that these are bugs that are very well adapted to human dwellings which we often keep at relatively constant temperatures and honestly just make it really, really easy for them to live for a long time. So in cooler conditions, then they can live for potentially up to a year or more. If we keep our houses warmer, then maybe they're living for just a handful of months, like 4-4.5 months or so and taking only a few two weeks or a couple of months to actually develop fully into adults. But certainly they are susceptible to environmental conditions. They also can't survive a good vacuuming.

Erin Welsh

Okay.

Erin Allmann Updyke

Put them in a vacuum bag. And then freezers will kill them, hot, hot water, like washing all of your things with super hot water and then put them in the dryer, those things will kill them. So they're not like a prion that's like impossible to denature.

Erin Welsh

Right. So I guess this is kind of because this isn't our usual fare, at this point you would normally talk about treatment.

Erin Allmann Updyke

Yeah.

Erin Welsh

But are you going to talk about like pesticides or like what are you going to talk about?

Erin Allmann Updyke

No, I don't really have anything honestly.

Erin Welsh

Okay.

Erin Allmann Updyke

You can treat the itching, right, like topical steroids, systemic antihistamines, itch relief. That's all I have in terms of treatment. I'll talk more, well maybe I won't really actually. So let's talk about it now. I was gonna say I'll talk more about how you get rid of bed bugs later on but I won't really. What I will talk about is how insecticides aren't going to do you pretty much any good because bed bugs have incredible resistance to pretty much all of the insecticides that we use.

Erin Welsh

Yeah. That ship has sailed.

Erin Allmann Updyke
Yeah. So it really is like identifying that these bugs exist, finding their refugias, and then cleaning the heck out of them in order to get rid of them, which is really the only thing that you can do to actually treat the issue of bed bugs.

Erin Welsh
Simple enough.

Erin Allmann Updyke
Simple enough.

Erin Welsh
It's not but yeah.

Erin Allmann Updyke
It's not simple at all.

Erin Welsh
It sounds like it is.

Erin Allmann Updyke
And as I'll mention later on, it's also incredibly costly especially when we look at how quickly these can spread and therefore how intensive the efforts have to be in order to eliminate them, especially when we're looking at things like apartment buildings where you have a lot of housing units in one building, hospitals, hotels, cruise ships, like any place where you have a lot of people sharing space, especially sharing bedding. It's a major, major issue trying to kind of actually get rid of all of these.

Erin Welsh
Yeah.

Erin Allmann Updyke
But that's primarily bed bugs and the issues that they cause for us as humans. Erin.

Erin Welsh
Yes, Erin?

Erin Allmann Updyke
Tell me have they always been with us? I'm guessing, I have some guesses here. How did we get here to where we are today? Tell me about these little bugs.

Erin Welsh
Yeah, there's a lot to tell. So I better get started right after this break.

TPWKY
(transition theme)

Erin Welsh
I think that the best way to talk about the evolutionary history of bed bugs is to first talk about what we used to think we knew so that we can then appreciate how that history has almost been completely rewritten in the past few years.

Erin Allmann Updyke
Ooh, love.

Erin Welsh

So like you mentioned Erin, when we talk about bed bugs in the context of human infestations, we are generally talking about these three species. You talked about the two, the common bed bug and the tropical bed bug, *Cimex lectularius* and *Cimex hemipterus*. And then there's also mentioned commonly as a human biting bed bug is *Leptocimex boueti*. And these are three species like you said out of a family of over 100 species I think at this point. What do these other species of bed bugs do? Well they all feed on blood but generally speaking that blood either belongs to water birds, other birds, or bats. But if you look at the evolutionary relationships among all of these other species in the Cimicidae family, stuff like which species are oldest, which are more closely related than others, which evolved most recently, what researchers found by looking at these things is that the oldest of these species, the one that is closest to the forms that are now extinct, they feed on bats, which would reasonably point towards bats acting as the earliest hosts of all bed bugs. So the story would go that ancient bed bugs encountered bats and fed on their blood occasionally until occasionally became obligately as the bed bugs began to rely on these mammals for their food.

Erin Allmann Updyke

Got it.

Erin Welsh

And so the story continues that when early humans began moving into caves for shelter, bed bugs were already there feeding on bats. And then these bed bugs were like oh hey, it's free real estate, here's a brand new host that we can take advantage of. And then as ancient humans evolved into different species and then spread across the globe, they took bed bugs with them, which subsequently evolved into different species. That is how the story went for a very long time. But that story is now a 'or so we thought' type of story.

Erin Allmann Updyke

Ooh!

Erin Welsh

So there's a paper from 2019 in Current Biology by Roth et al that puts it pretty plainly in the title. Quote: "Bed bugs evolved before their bad hosts and did not cospeciate with ancient humans."

Erin Allmann Updyke

The end.

Erin Welsh

Do I need to say anything more?

Erin Allmann Updyke

No. Except maybe like what, why, how?

Erin Welsh

I may not need to but I will. So it turns out that the earliest fossil of a close relative of bed bugs would put the origin of bed bugs back to about 100 million years ago, so like dinosaurs.

Erin Allmann Updyke

Dinosaurs.

Erin Welsh

Yeah, exactly.

Erin Allmann Updyke

I love when we talk about bugs feeding on dinosaurs!

Erin Welsh

I know, I know. We should somehow try to find a way to do a whole episode about it. I don't know how.

Erin Allmann Updyke

Especially a bed bug because there's so little, Erin. How do they pierce dino skin?

Erin Welsh

That's a great question.

Erin Allmann Updyke: I love this.

Erin Welsh: I don't know. But the other really cool thing is that they probably did because when these bed bugs evolved 100 million years ago, they were already pros at blood feeding.

Erin Allmann Updyke: What?

Erin Welsh: They were already obligate blood feeders it appears rather than as we had thought, sort of slowly incorporating it into their lifestyles.

Erin Allmann Updyke: What?

Erin Welsh: And so that means that their ancestor also already specialized on blood. But whose blood?

Erin Allmann Updyke: Whose blood?

Erin Welsh: We don't know.

Erin Allmann Updyke: We'll never know.

Erin Welsh: Probably not bats unless we're totally wrong about bat evolution, since the earliest known bats didn't emerge until I read around 30 million years after bed bugs did. That's a long time.

Erin Allmann Updyke: That's a pretty long time.

Erin Welsh: Yeah. So which animal or animals served as the earliest host of bed bugs? Total mystery at this point. But from those mystery hosts, bed bugs found their way onto bats.

Erin Allmann Updyke: Okay.

Erin Welsh: And then onto birds and then back to bats or from one species of bats to another species of bats and so on, diversifying along the way.

Erin Allmann Updyke: Okay.

Erin Welsh: And so the three bed bug species that feed on humans arose as part of this diversification process and the species themselves were already established before they started feeding on humans. In fact these species emerged around 5-10 million years before any member of the Homo genus existed.

Erin Allmann Updyke: Wow.

Erin Welsh: Yeah.

Erin Allmann Updyke: Old.

Erin Welsh

Very old. Unlike this previous story that we used to tell about bed bugs and humans and bats and so on, the evolution of these generalist bed bug species didn't happen alongside ancient human evolution into new species but rather that these bed bug species were introduced to humans in three independent events. When those events occurred and which early human species were first parasitized, we still don't know that or don't know that yet maybe.

Erin Allmann Updyke

Okay.

Erin Welsh

But what does this mean for us today? In terms of how we deal with bed bugs, probably not much. That's more about insecticides and creative treatment strategies and so on. But it does bring up many interesting questions about the human history of these bed bugs. How co-evolution of humans and bed bugs didn't seem to happen in the ways that we thought it did as well as something I find super interesting, which is what drives host switching. Like why does a bed bug feed on one species and then feed on a different species?

Erin Allmann Updyke

Right.

Erin Welsh

Or why does a bed bug start to feed on multiple species?

Erin Allmann Updyke

Yeah.

Erin Welsh

And then these trade offs between being a parasite that specializes on just one species or a parasite that's a generalist.

Erin Allmann Updyke

Yeah.

Erin Welsh

That's like I want to feed on everything. And then like can it happen where a specialist becomes a generalist and then goes back to a specialist? Like there's so much there that's absolutely fascinating. And that is honestly like bed bugs are such a great group of organisms to study that, like host switching and specialists and generalist tradeoffs. And I love it. I love it. I could spend the whole episode talking about that aspect of it but I think I should probably should talk a little bit about the human history of these little bugs. The beginnings of the long and fruitful and frustrating relationship between humans and bed bugs, that might be a bit murky still. But we can speculate at least that as humans settled in larger groups and built permanent or semi permanent shelters, bed bugs were there to keep them company or at least they arrived shortly after, adapting to the diurnal sleeping patterns of humans which is-

Erin Allmann Updyke

So cool.

Erin Welsh

So amazing.

Erin Allmann Updyke

Yeah.

Erin Welsh

As well as our less hairy bodies compared to bats.

Erin Allmann Updyke

Oh wow.

Erin Welsh

So like they had to crawl, scuttle differently. I mean everything about it is...

Erin Allmann Updyke

I never thought about that but yeah.

Erin Welsh

It's so cool. In terms of archaeological evidence, the oldest evidence of bed bugs cohabitating with humans dates back to around 3500 years ago in Ancient Egypt. So there were preserved bed bugs that were identified as *Cimex lectularius* found in a city called Akhetaten in the times before King Tut in the place where tomb builders and guards likely slept. So in a sleeping chamber.

Erin Allmann Updyke

Okay.

Erin Welsh

And they hung around, as evidenced by a papyrus from about 1000 years later that described a spell to keep them away. And the bed bugs also spread, popping up in what is now Iraq by at least the 9th century, they appear in ancient religious texts such as the Talmud. If we take the archaeological samples from Ancient Egypt as sort of the origin point and then also use that in combination with these references in ancient texts to bed bugs, we can assume, we can guess that the bed bug spread from Ancient Egypt to the Middle East and then to Europe and Asia. And many of these ancient texts talked about bed bugs the way you might expect them to, the way that we talk about bed bugs today as bothersome pests, how to look for signs of bed bugs, how to keep them away and so on. But at least a few of these ancient scholars had a kind of when life gives you lemons, make lemonade outlook.

Erin Allmann Updyke

Stop it.

Erin Welsh

But instead of lemons it was like when life gives you bed bugs, make a potion with meat and beans or wine to treat fevers, cure snake bites, or get leeches off of you.

Erin Allmann Updyke

Like from the bugs? Like you take the bugs and you make them into a little potion?

Erin Welsh

Yeah, ground bed bugs.

Erin Allmann Updyke

Ground up bed bugs. Love it.

Erin Welsh

The beans kind of cracked me up. And I think that Pliny the Elder also was skeptical of the beans but he did support the use of bed bugs to treat earaches by burning the bugs, combining their ashes with rose oil, and injecting it.

Erin Allmann Updyke

Into what?

Erin Welsh

Yourself. I guess your ear canal, I don't know.

Erin Allmann Updyke

Not your ear. I have a real thing about bugs and ears.

Erin Welsh

I know this about you.

Erin Allmann Updyke

So I, oof. That gets me,.

Erin Welsh

You know we love these ancient cures but in the case of bed bugs, they weren't just ancient cures.

Erin Allmann Updyke

Okay.

Erin Welsh	The 1896 edition of the American Homeopathic Pharmacopoeia includes a recipe for a tincture, 1896, of bed bugs to treat malaria. Other uses of bed bugs included to treat constipation, coughs, hemorrhoids, liver complaints. What is a liver complaint? I've always wanted to know. Skin ailments, frequent yawning, among many other things.
Erin Allmann Updyke	I literally don't know what to say.
Erin Welsh	You know I'm guessing it's because they were there and they were abundant and it was like surely there must be a reason why these things exist.
Erin Allmann Updyke	I can use these.
Erin Welsh	Anyway.
Erin Allmann Updyke	Okay.
Erin Welsh	The ways that you could ward off bed bugs in the ancient world were just as inventive as the uses for the critters. So according to the Greek philosopher Democritus around 400 BCE, you should hang the feet of a hare or a stag at the foot of your bed to keep the bed bugs away.
Erin Allmann Updyke	Okay.
Erin Welsh	An alternative solution would be to hang a bear skin or put a bowl of water under your bed while you're traveling.
Erin Allmann Updyke	Okay.
Erin Welsh	Speaking of traveling, of course the bed bug was a very frequent and successful hitchhiker. So it arrived in Greece at least by 420 BCE, Italy by 77 CE, China by 600 CE, Japan around the same time, Germany by the 11th century, France by the 13th, England by the 16th, and on to the Americas with some of the earliest trips of boats going over there. As the bed bugs spread across the world, it's not like it was a few bugs that popped up here and there. The bed bug is an incredibly successful establisher, right. Like once it got brought to a new place, it survived, it thrived, really to the point where it became so prevalent in their new places of residence that they earned their fair share of names, like these different local names that were used to describe these bugs. So let's get into a couple of these names.
Erin Allmann Updyke	Okay.
Erin Welsh	In Ancient Greece the word they used was 'coris' which means to bite and allegedly gave rise to the name for coriander because when you crush the fresh leaves and seeds, it's supposed to give off a smell like that of crushed bed bugs.
Erin Allmann Updyke	Fascinating.
Erin Welsh	Yeah. The name Cimex was given to the bugs by scholars in Ancient Rome, 'cimex' meaning bug. And later of course that would become its genus name along with the species name lectularius which was supplied by Linnaeus in the 1700s. And 'lectularius' translates to quote "of the bed or of the couch". Bug of the bed.
Erin Allmann Updyke	Bug of the bed.

Erin Welsh

It's apt. In Ancient China the bugs were generally called stinky bug, which is also similar to what people in France called them when the bed bugs arrived there in the 13th century. And in Japan floor bug or floor louse. In Spain, chinche. In Germany, the newly arrived bed bugs as of the 11th century would be called various names that translated to the following: nightcrawler, paper flounder, and little venereal. But the English word was short and sweet and so perfect that it literally has stood more than the test of time. Bug. Not bed bug, just bug.

Erin Allmann Updyke

Just bug.

Erin Welsh

So that's where the word bug came from was bed bugs, that's what it's referring to.

Erin Allmann Updyke

Stop it, from bed bugs? Are you serious?

Erin Welsh

That's what I took from this research.

Erin Allmann Updyke

Fascinating.

Erin Welsh

Yeah, yeah. As the bed bug found its way into city after city, home after home, it acquired more names along the way, like red coat and mahogany flat in what would become the US. And it also lent its name to towns like Bed Bug Hill, New Jersey, which I think only exists as Bed Bug Hill Road these days. And the California mining town that was named, it kind of like switched between names, either Bed Bug or Freeze out.

Erin Allmann Updyke

Okay.

Erin Welsh

I guess Bed Bug in the warmer months and then Freeze Out in the colder months.

Erin Allmann Updyke

Freeze Out.

Erin Welsh

As the bed bug found its way into our homes, our suitcases, and our beds, it also began to occupy a bigger and bigger portion of our hearts and minds. This is at least how I am going to think of it. Basically what I mean by that is that people began to write about the bed bug and include it in novels, poems, paintings, songs. You can find references to bed bugs in works by Upton Sinclair, Sinclair Lewis, Langston Hughes, John Steinbeck, so many others. And bed bugs featured prominently in many early blues songs like Black Snake Moan by Blind Lemon Jefferson and Mean Old Bed Bug Blues, as well as country songs and calypso songs. And bed bug didn't always mean bed bug of course but sometimes it was a little bit of an innuendo term, like eyebrow.

Erin Allmann Updyke

Venereal.

Erin Welsh

Little venereal. Yeah, it would be like the bed bug wants to sneak under the covers and bite this lady's butt or something like that.

Erin Allmann Updyke

Ooh okay.

Erin Welsh

Yeah. You should look up some of these lyrics. But just because the bed bug started to be included in music and art and literature, it didn't mean that people were like you know what? Okay. I guess bed bugs are here to stay, let's just welcome them with open arms and lift the covers to hop on in. The battle to get rid of these bugs and stop them from spreading was constant, like absolutely constant and frustratingly, largely unsuccessful or at least we can assume so given the frequent turnover and wide variety of treatment options. You could use the smoke of ox dung, horse hair, arsenic, these are all smokes, lupines, and cyprus. You could combine saltpeter, soft water, shaving soap, and aqua ammonia. You could put on a night light and drizzle turpentine over your sheets and pillows.

Erin Allmann Updyke

Don't, please don't.

Erin Welsh

Yeah, yeah, right. I feel like especially that last one, turpentine in your sheets-

Erin Allmann Updyke

Yeah.

Erin Welsh

Kind of shows that if you're willing to inhale arsenic smoke all night or sleep in turpentine soaked sheets, the bed bugs must have been horrible.

Erin Allmann Updyke

Right. A real, real issue.

Erin Welsh

Real issue. And there is one account, who knows if it's an exaggeration, probably, but it described how in the 19th century US bed bugs could be scooped from the walls of sod houses and measured with a spoon.

Erin Allmann Updyke

That's incredibly gross.

Erin Welsh

And our firsthand accounts were just a couple from so many describing the horrors of having to spend a night in an incredibly infested room or bed. And I couldn't resist including a few more in here.

Erin Allmann Updyke

Please.

Erin Welsh

Because there are so many just like... Yeah.

Erin Allmann Updyke

I'm so itchy.

Erin Welsh

From the Reverend James Woodford describing his 1786 stay in London, quote: "I was bit so terribly with bugs again this night that I got up at 4 o'clock this morning and took a long walk by myself about the city until breakfast time." The next night, quote: "I did not pull off my clothes last night but sat up in a great chair all night with my feet on the bed and slept very well considering and not pestered with bugs." Endquote.

Erin Allmann Updyke

Okay.

Erin Welsh

Yeah. Or a description given to Henry Mayhew of a lodging house in London, quote: "In the morning he drew, for purposes of ablution, a basin full of water from a pail full kept in the room. In the water were floating dead or apparently alive bugs and lice which my informant was convinced had fallen from the ceiling, shaken off by the tread of someone walking in the rickety apartments above."

Erin Allmann Updyke

Aye aye aye.

Erin Welsh

Yeah. Apparently the bed bugs were so bad in some of these lodging houses that people were told you should get half drunk to get a decent night's sleep because the bed bugs will keep you up.

Erin Allmann Updyke

Wow.

Erin Welsh

They could be seen quote "crawling from house to house, escaping through exterior windows and doors and traveling along walls, pipes and gutters." Endquote. I mean that has to be an exaggeration but I don't know.

Erin Allmann Updyke

I don't know.

Erin Welsh

Yeah.

Erin Allmann Updyke

I will say when you asked can you feel the bugs, I feel like you would feel those.

Erin Welsh

Yeah.

Erin Allmann Updyke

Like that you would feel.

Erin Welsh

Yeah.

Erin Allmann Updyke

Yeah.

Erin Welsh

These are not... These are massive-

Erin Allmann Updyke

Not subtle.

Erin Welsh

Massive numbers.

Erin Allmann Updyke

Yeah.

Erin Welsh

And this is my favorite quote, I've read so many but this is my favorite. Quote: "Here nearly every house is a haunted house. After dark there is no place more eerie, no torture more prolonged and blood curdling than that enacted here year after year, no atrocity more revolting than the nightly human sacrifice. For there are vampires, I have seen them. I have smelt them."

Erin Allmann Updyke

Aye aye aye.

Erin Welsh

Yeah. The bed bug situation was truly a nightmare. As John Southall pointed out in his 1730 'A Treatise on Bugs', he called them a nauseous, venomous insect. Clearly this was not going to be a live and let live situation.

Erin Allmann Updyke

No.

Erin Welsh

And that's mostly what I'm going to focus on for the rest of the history section. By the 1600s, 1700s, there was no more land left undiscovered by bed bugs. They were everywhere. It had become a matter of war between humans and bed bugs. And the first weapon to be employed in this war was hand to hand combat, which was as you can imagine highly unpleasant. From a 1673 description, quote: "This insect, if it be crushed or bruised, emits a most horrid and loathsome stench so that those that are bitten by them are often in doubt whether it be better to endure the trouble of their bitings or kill them and suffer their most odious and abominable stink." Yeah. Endquote.

Erin Welsh

And while manually smooching bugs always remained a viable and sometimes necessary option, there are only so many bugs that you can smooch in a night and other strategies evolved to deal with the growing infestations, namely prevention and then chemical and non chemical control techniques. But most importantly, vigilance. There is so much more literature on the history of bed bug management than I ever expected and it is absolutely riveting and hilarious. And so you should definitely check out some of these papers that I'll mention at the end because I'm only going to cover so much here. So let's get to it. England's first bed bug exterminators began popping up in the late 17th century. The most famous of which was Tiffin and Son of London who exclusively served to the nobility and who advertised themselves as quote "may the destroyers of peace be destroyed by us. Tiffin and Son, bug destroyers to Her Majesty." Endquote.

Erin Allmann Updyke

Love it.

Erin Welsh

They were so like snobby and classist. They said, this is literally a quote, "I work for the upper classes only."

Erin Allmann Updyke

Wow.

Erin Welsh

And then this quote, "my work is more method and I may call it scientific treating of bugs rather than wholesale murder." Which is like okay. And the main strategy that Tiffin and Son used for bed bug control was prevention by constantly monitoring and checking for bugs. And among other things, they recommended inspecting everything as much as possible, especially secondhand furniture or linens, moving into an old house, stuff like that. And one of my favorite things that I learned about bed bugs is how they drove bed design.

Erin Allmann Updyke

What?

Erin Welsh

They changed the way beds were designed or at least had played a major role.

Erin Allmann Updyke

Stop.

Erin Welsh

Okay. So when you picture a fancy bed in nobility from the Renaissance, what do you picture?

Erin Allmann Updyke

I don't know, like the posts and like drapes and things?

Erin Welsh

Yeah. Like you can turn it into like a little cave. Yeah. There are tons of curtains around it and everything.

Erin Allmann Updyke

Yeah.

Erin Welsh

Really ornately carved designs maybe.

Erin Allmann Updyke

Right. Lots of crevices.

Erin Welsh

Yeah. Yeah, no more crevices was the advice. So John Southall who called bed bugs that nauseous, venomous insect, he recommended that people should make beds as wood-free as possible, easy to disassemble, and have fewer nooks and crannies for the bugs to hide in. So get rid of those velvet curtains, get rid of those tassels, get rid of the ornately carved wood. That's all prime bed bug real estate.

Erin Allmann Updyke

I mean yeah.

Erin Welsh

Yeah. And I just thought that was so interesting, sort of this need to constantly disassemble and reassemble beds was because of bed bugs, right, to treat and watch for bed bugs. Sometimes it would be like oh you should make it with this type of wood, not that type of wood because this type of wood is repellent, whatever. But bed design in hospitals especially made a big impact because hospitals were often hugely infested. There's a quote to support this. Quote: "Bugs are frequently a greater evil to the patient than the malady for which he seeks a hospital." Endquote.

Erin Allmann Updyke

Oh man. The number of times I feel like we've talked about things that kill you in hospitals that are not the thing that you went there for on this podcast.

Erin Welsh

And so many hospitals started to use iron beds.

Erin Allmann Updyke

Yeah.

Erin Welsh

Beds entirely made out of iron to combat the bugs.

Erin Allmann Updyke

I feel like that's so interesting because that's what I picture like old timey hospital beds are, right. Just like those metal frame beds.

Erin Welsh

Yeah. Yeah, exactly. And so to have this metal frame bed was really a big benefit when you were pouring boiling water or arsenic or applying sulfur in the crevices, when you needed to pull the beds away from the walls, stand them in pails of oil, you wanted to douse the slats or springs or crevices in bacon grease. I mean okay, these things were not always great choices or effective choices. Could you just imagine the smell of like rotting bacon grease on your bed?

Erin Allmann Updyke

Please stop.

Erin Welsh

But having iron beds really helped with that constant treatment that they needed. If you weren't using bacon grease, you could also use these highly guarded patent formulas like PDQ, Pesky Devil's Quietus or pyrethrin powder which is an insecticide derived from plants, chrysanthemums. The point is there were many different options at your disposal. But despite if you used every single one of these options, despite if you hired the most reputable exterminator, despite keeping a constant watch for the bugs, you couldn't be sure that you would defeat them. And the problem would only get worse during the Industrial Revolution as people flocked to the city in droves. Throughout the late 1800s and into the early 1900s, bed bugs were for sure winning the war. There was really no contest. Infestations went from seasonal to year round as population density went up, apartment density went up, and central heating began to be incorporated into buildings which allowed bed bugs to just keep living their best life year round.

Erin Allmann Updyke

Year round, baby.

Erin Welsh

I read one paper that estimated about a third of dwellings in major European cities in the 1930s and 1940s were infested and half of London had bed bugs. The western hemisphere was no different. In 1895 a lawsuit in Chicago concluded with the jury ruling that no one should pay rent in a house that was infested with bed bugs and newspapers were like no one in Chicago is going to be paying rent then. Many landlords began to require and some still do a prospective tenant to disclose any history with bed bugs. And that of course discriminated against those earning low incomes who tended to be at higher risk of exposure to bed bugs. But no one was truly exempt from the threat of bed bugs. They were found on buses, taxis, trains, planes, and automobiles, inside televisions and radios, at repair shops, at the theater, library, hospitals, schools, daycare, prisons, hotels, office buildings, restaurants, fire and police stations, stores, funeral homes, everywhere.

Erin Allmann Updyke

Still true.

Erin Welsh

Yeah, still true. Soldiers during WWI and WWII were engaged in another war alongside the political one as bed bugs prospered, they invaded the cork lining of helmets and they bit soldiers heads.

Erin Allmann Updyke

Oh no!

Erin Welsh

They occupied every possible bunk in living quarters causing such a morale issue during WWII that there were congressional hearings to figure out how to get rid of these bugs.

Erin Allmann Updyke

Wow.

Erin Welsh

Which ultimately led to the most effective, economical, and apparently safer to humans anyway solution that the world had ever seen in the fight against bed bugs, DDT.

Erin Allmann Updyke

DDT.

Erin Welsh

Aka dichlorodiphenyltrichloroethane. I think I got that right.

Erin Allmann Updyke

I think you nailed it.

Erin Welsh

By the 1940s, the world had come a long way from the bacon grease ointment days of the 1700s or 1800s. But while some of these insecticides may have worked against the bugs, they were also often deadly to humans because they included things like cyanide gas, mercury chloride, phenol, kerosene and so on. DDT on the other hand was also toxic but less so. It also didn't have to come into contact directly with the bugs to work, like you could kind of just set it and forget it and it would last for much, much longer than many of the other compounds which would lose efficacy after like a few hours. I'm not going to tell the epic story of the rise and fall of DDT because I think we're planning on covering it later this season.

Erin Allmann Updyke

I thought also you've touched a lot on it in our dengue episode and maybe a couple of others.

Erin Welsh

I have no memory of that at all.

Erin Allmann Updyke

You've definitely at least mentioned like all of that story.

Erin Welsh

Okay.

Erin Allmann Updyke

Yeah.

Erin Welsh

Well I'm going to just real quick go through a couple of things especially as it pertains to bed bugs. So DDT was first synthesized in 1874 but mostly forgotten about for like 65 years or so. And then in 1939 when it was rediscovered by a Swiss chemist named Paul Müller who would later go on to get a Nobel Prize for this, DDT was found to be incredibly effective like I said and so it was shortly deployed all around the world to kill everything including bed bugs. And you could find it and buy it anywhere. It seemed like a miracle. In the short term, in terms of bed bug control, it was. Within 5-7 years of when DDT was available, researchers had a really hard time finding any bed bug populations that they could research.

Erin Allmann Updyke

What?

Erin Welsh

And by the 1960s, infestations in most industrialized countries were rare. Bed bug awareness campaigns fell by the wayside and I would bet that if you plotted the number of research articles about bed bugs from the early 1900s to today, you'd see a big boom up to the 1940s and then a crash in the 1950s, 1960s. And then-

Erin Allmann Updyke

And then?

Erin Welsh

Yeah. And then it comes back up. First resistance to DDT which happened pretty soon after its introduction of course and then the prohibition of DDT for very good reasons, meant that bed bugs slowly rebounded. And that slow trickle of papers in the 1970s may be reporting on like oh resistance here, oh a case here, that would turn into this full on wave in the early 2000s as bed bugs found their way back into our beds, our couches, our futons, our beanbags, our homes. The first time that bed bugs might be back came in 1998 in the form of an article describing an apparent increase in bed bug bites in Cambridge, England. And notably this article mentioned how no insecticide seemed effective. A couple of years later a report from the US also mentioned that bed bug bites might be on the rise. And in 2001 Venezuela reported the first instance of bed bugs in 30 years. Anecdotes then turned into data which put a number to the bed bug resurgence. In the UK between 1997-2000, a sixfold increase in bed bug infestations. In Australia between 1999-2006, a 4500% rise in bed bug numbers.

Erin Allmann Updyke

Australia's numbers are bananas and they were like the easiest to find. So it's fascinating to me, like Australia doing a great job counting but whew.

Erin Welsh

Interesting.

Erin Allmann Updyke

Yeah, yeah. A lot of the papers that I read were from Australia.

Erin Welsh

Yeah. These numbers are hard to... Because they're also different.

Erin Allmann Updyke

Yeah.

Erin Welsh

But they're a percent, they're whatever.

Erin Allmann Updyke

Right.

Erin Welsh

And so for instance those numbers in Australia were over a 7 year period. whereas in the US in one year, 2002-2003, it was a 500% increase in calls about bed bugs.

Erin Allmann Updyke

Right.

Erin Welsh

Like how do you measure that in prevalence?

Erin Allmann Updyke

What's does that mean?

Erin Welsh

Yeah. But I mean regardless of like how to relate these numbers to each other, what they really mean, it's pretty obvious that this is a global trend. What drove this rise in bed bugs? I mean it seems like there are a lot of different factors at work here but most people point towards the rise in insecticide resistance, increased global travel, as well as a lack of public awareness at least in the early days of their reemergence. People thought that bed bugs were a problem of the past, right. Bed bugs certainly occupied the headlines for a long time with horror stories and warnings of if you step one foot into this infested place, you're doomed forever and you'll have to throw away your entire apartment and everything. And that all led to an incredible amount of shame and stigma and misinformation and disinformation surrounding something that it's really hard to have control over in your own life. And I feel like that's something that throughout this episode we're talking about it's so horrible to think about these bugs crawling on you in your bed or whatever. And it is but I feel like that sort of reaction is part of this whole aspect of shame and stigma and blaming.

Erin Allmann Updyke

Totally.

Erin Welsh

Yeah. So I don't know, I don't really have a good wrap up point here. But I guess that as I was writing this I was thinking I remember when bed bugs were dominating headlines but I don't feel like I've read that much about them lately. And so is there still a rampant bed bug problem? Have we just gotten accustomed to it? What's going on with bed bugs today, Erin?

Erin Allmann Updyke

Oh okay. Let me try and answer that question right after this break.

TPWKY

(transition theme)

Erin Allmann Updyke

To answer your question briefly, yeah, yeah.

Erin Welsh

Okay. I figured.

Erin Allmann Updyke

They're still a thing, they're still increasing, they're still spreading. They show no signs of stopping in homes, in hotels, trains, cruise ships, buses, public transportation, office buildings, health care facilities, poultry farms. I don't know why those always come up. Across the globe, every single continent except Antarctica, they're endemic. They're here with us. The decline that we saw from the use of DDT and other insecticides in the mid 1900s wasn't equal across the globe unsurprisingly. But the resurgence has been global without a doubt. And the spread of insecticide resistance, like you mentioned Erin, has been thought to be one of the real driving forces behind this resurgence and insecticide and pesticide resistant bed bugs are found across the globe. But this is also in combination with increased global travel that facilitates the spread of these bugs in our luggage and on our clothes and in our towels, etc.

Erin Allmann Updyke

And so this has allowed for the spread of the two major species that I mentioned, the common bed bug and the tropical bed bug, across the globe. So we really don't see like a true dichotomy in these populations like we maybe used to in the past, with the tropical one mostly being in the tropics and the common one mostly being in temperate areas, they're both really widespread today. The other thing that compounds this that I find really interesting is that for the most part across the globe, in the US, in Europe, everywhere, there aren't centralized monitoring systems for bed bugs. And so the data that we have comes primarily from pest control companies themselves which is very interesting. And this lack of centralized reporting and relying on private companies means that we're going to have huge differences in how this data is collected as well as how infestations are actually dealt with.

Erin Welsh

Yeah.

Erin Allmann Updyke

And so there is a lot of data that suggests that the way that bed bug infestations are dealt with can vary widely which can contribute to continued spread or worsened spread because they're not actually being dealt with properly. And some of the data, I will say that a lot of companies are collecting a lot of this data which is shocking. Like in the US in 2015, studies I think by Orkin suggested that 80% of hotels in the US dealt with at least one infestation in that year. 80% of hotels in the US.

Erin Welsh

Wow.

Erin Allmann Updyke

Yeah. And like you mentioned, some of the numbers out of Australia, like thousands of percent increase in reporting, in numbers, etc, etc. They're everywhere.

Erin Welsh

They're everywhere.

Erin Allmann Updyke

And they're not going to go anywhere. That's I think the biggest, the reality of it.

Erin Welsh

Yeah.

Erin Allmann Updyke

One thing that I want to talk about because it's this podcast and because it's just fascinating is that every other time that we have talked about an insect on this podcast, we have talked about the pathogens that that insect is spreading to humans. We have talked about those insects as vectors, fleas, lice, mosquitoes, ticks, all of them as vectors of disease, infectious disease. Listeners you may have noticed in the biology section I didn't mention that at all.

Erin Welsh

What's going on?

Erin Allmann Updyke

What's up with that? So I want to talk about it a little bit because I think it's one of the most interesting areas of future research for bed bugs. The idea of bed bugs as a vector of infectious diseases, like every other blood sucker that we've ever talked about on this podcast, is not anything new. But the central dogma across all of the literature is that bed bugs are not vectors, bed bugs do not transmit disease. It's repeated over and over, that is what the CDC says, that is the official statement. But here's the thing, it's not because they can't. And we know this now today because plenty of studies that go back way longer than I realized actually demonstrate that the, and I'll quote here, "natural transmission cycle of multiple human pathogenic microbes can be completed in bed bugs," endquote, when they are artificially infected under laboratory conditions. So a lot of different studies have infected bed bugs with various microbes and been able to have those microbes grow in the bed bug and then actually be passed by the bed bugs, be shed by the bed bugs. The list of these pathogens includes but is not limited to Chagas disease, *Trypanosoma cruzi*, *Bartonella quintana*, aka trench fever, louse-borne relapsing fever, *Borrelia recurrentis*, various other rickettsias, possibly *Yersinia pestis*, aka plague.

Erin Welsh

Okay.

Erin Allmann Updyke

And there are probably more. So previously it was really thought that physiologically, biologically bed bugs just can't transmit disease. But that's not true because we know that biologically bed bugs can become infected, various pathogens can undergo whatever things they need to in this bed bug, in the the vector host that they would normally do in say a kissing bug, they can do that in the bed bug, and then the bed bugs can shed these pathogens. And yet we still don't have any convincing evidence that bed bugs are in fact transmitting any of these diseases in real life.

Erin Welsh

I mean I feel like that makes sense because first of all if you think about a mosquito or a kissing bug or a tick or whatever, compared to bed bugs there's not as much host hopping. Because a bed bug is living in your bed, so it's going to feed on the same person night after night after night after night.

Erin Allmann Updyke

Potentially. But in a hotel you've got a different person in that bed every single night.

Erin Welsh

It's true but it's still very different. I feel like it's still very different. I feel like it's ecologically limiting in that way.

Erin Allmann Updyke

Right. So that's the big question is if it's not because of a biological barrier, then is it an ecological barrier?

Erin Welsh

Well and then the other thing too is thinking about because all of the pathogens that you described have different transmission routes.

Erin Allmann Updyke

Right.

Erin Welsh

So the fact that a bed bug will shed these different pathogens, is that enough for infection?

Erin Allmann Updyke

Right, right. Well but we can for example in the case of *T. cruzi*, go on to infect other animals from bed bugs, right, under laboratory conditions.

Erin Welsh

But how often is one bed bug encountering all these different animals?

Erin Allmann Updyke: It's 100%, these are all of the questions that I think are so interesting and fascinating. Because yes, what this tells us is that it's potentially ecological environmental factors that are precluding bed bugs from serving as vectors in their natural environments.

Erin Welsh: Yeah.

Erin Allmann Updyke: But what are those specific barriers and under what conditions could they potentially be overcome if the conditions of human bed bugs interactions change in the future?

Erin Welsh: Yeah. I think that's interesting to think about in terms of historical infestations of bed bugs when they were like much, much higher and maybe they did have more opportunities to play a role in human to human transmission of something.

Erin Allmann Updyke: Right? Yeah.

Erin Welsh: But it's hard to see nowadays necessarily. But like you said, it's possible.

Erin Allmann Updyke: Yeah. I think it's fun and interesting especially just because I think that the dogma for a long time was that because we've never seen sustained transmission of any human pathogens from these bed bugs, it must be that they're incapable of being vectors.

Erin Welsh: Right.

Erin Allmann Updyke: But now we know that that's not true biologically.

Erin Welsh: Right. What is the barrier? Is it a physiological barrier, probably not. But is it an ecological barrier, seems likely.

Erin Allmann Updyke: Yeah. Which I think is just so so interesting to think about it as an ecological and environmental barrier rather than a biological one. Especially because so many vectors that we talk about on this podcast are so specific, right?

Erin Welsh: Right.

Erin Allmann Updyke: It's like one pathogen, one vector. But bed bugs are over here like well we could do it but we're just not gonna.

Erin Welsh: I mean thank goodness.

Erin Allmann Updyke: Yeah. One less thing to stress about with bed bugs.

Erin Welsh: Yeah, yeah.

Erin Allmann Updyke: So yeah, that's what I have, Erin. Bed bugs, they're everywhere, they're itchy, but at least they're not giving us diseases.

Erin Welsh: As far as we know.

Erin Allmann Updyke: Well, sources?

Erin Welsh	Sources. I have a bunch, I'm gonna call out two in particular. One is by Roth et al, the one that I mentioned earlier, 'Bed bugs evolved before their bat hosts and did not cospeciate with ancient humans.' And then also the one I mentioned at the very top by Boynton from 1965 called 'The Bed-Bug and the Age of Elegance'.
Erin Allmann Updyke	I had a number of different papers. A couple of my favorites on just the general biology. One is titled 'The Biology of the Bed Bugs' in Annual Reviews Entomology from 2007. There was a great one from 2012 that was 'Bed bugs: clinical relevance and control options' in Clinical Microbiology Reviews. And then I've got a number of more papers on the bed bugs as vectors in the biology labs, so you guys can read more about that. On our website you can find the sources all of these from this episode and all of our episodes, thispodcastwillkillyou.com. That's where they'll be.
Erin Welsh	Thank you to Bloodmobile for providing the music for this episode and all of our episodes.
Erin Allmann Updyke	Thank you to Lianna Squillace our amazing sound mixer.
Erin Welsh	Thank you to the Exactly Right network.
Erin Allmann Updyke	And thank you to you, listeners, for listening.
Erin Welsh	Yeah.
Erin Allmann Updyke	This was a fun kind of different one.
Erin Welsh	Yeah, I hope that you don't regret sticking with it, this episode that made you itchy. And a special thank you to our wonderful, generous, so appreciated patrons. Thank you. Thank you. Thank you.
Erin Allmann Updyke	Thank you.
Erin Welsh	Well until next time, wash your hands.
Erin Allmann Updyke	You filthy animals.