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THE LITTLE-KNOWN WORLD OF CATERPILLARS

An entomologist races to find them before they disappear.

By Elizabeth Kolbert

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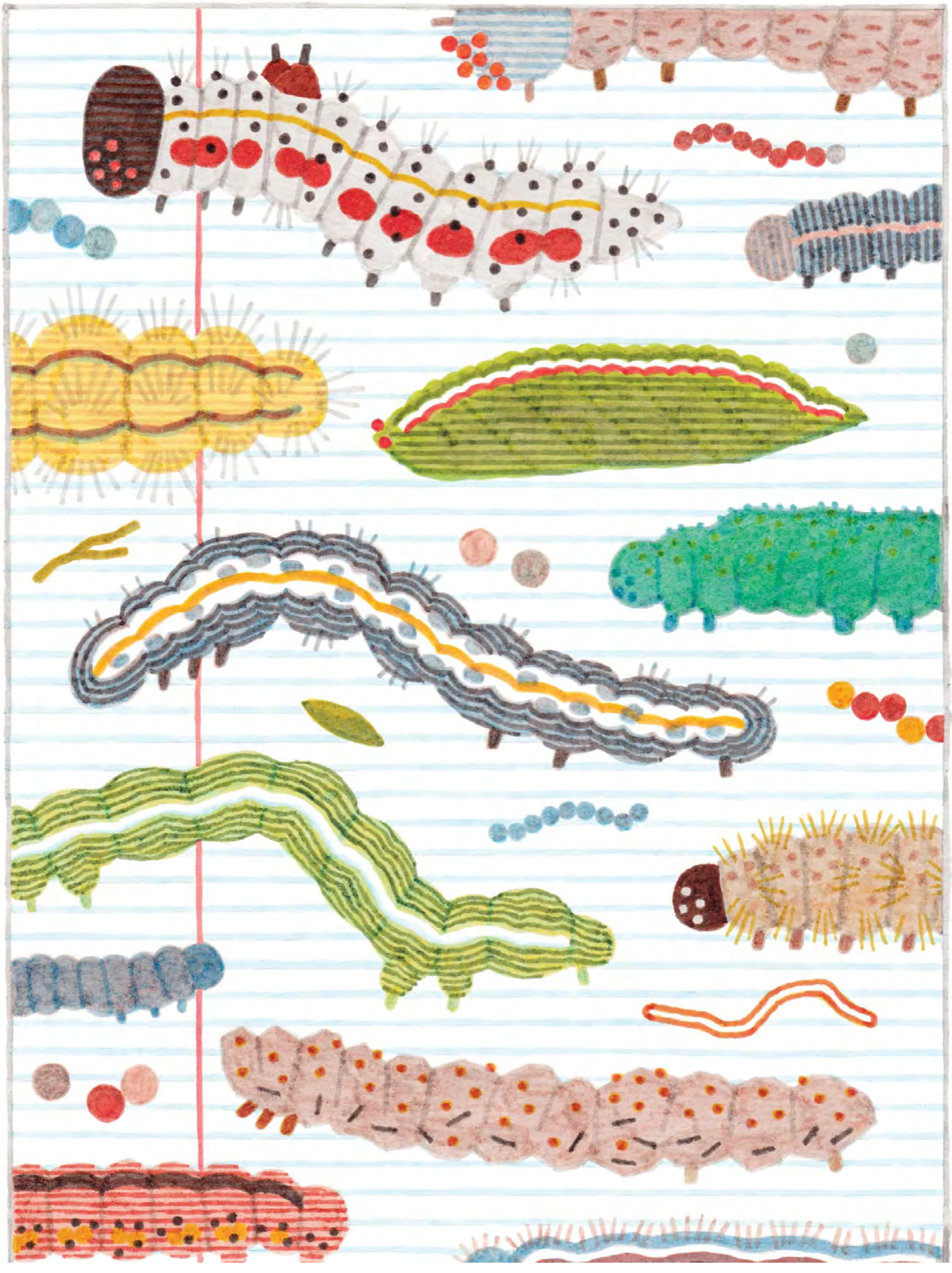

Some scientists warn of an insect apocalypse. The flying-insect community has been "decimated," a research paper said. Illustration by Jochen Gerner

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The Devils River, in southwestern Texas, runs, mirage-like, along the edge of the Chihuahuan Desert, through some of the most barren countryside in the United States. Access to the river is limited; unless you're in a kayak, the only way to travel upstream is along a skein of rutted dirt roads. It was on one of these roads that, a few years ago, David Wagner noticed a shrub that seemed to him peculiarly filled with promise.

Wagner is an entomologist who teaches at the University of Connecticut. He has close-cropped silvery hair and a square jaw and bears a passing resemblance to George C. Scott playing General Buck Turgidson. The way other people might recall a marvellous restaurant or a heartbreaking vista, Wagner remembers a propitious plant. He has friends who own a house along the Devils River, and each time he has visited them he has stopped by the exact same shrub to investigate. No luck. This past October, I was travelling with him when he tried yet again. He spread a white nylon sheet on the ground, then started whacking the bush with a pole to dislodge anything that might be clinging to it.

"Un-fucking-believable!" he exclaimed. I was whacking a plant nearby, just for the hell of it. Wagner held out his hand. A caterpillar about three-quarters of an inch long was wriggling across his palm. It looked brownish and totally ordinary until I examined it under a loupe, at which point it was revealed to be flamboyantly striped, with yellow and red splotches and two black, hornlike protuberances sticking out of its back. Based on a series of taxonomic calculations, Wagner was convinced that the caterpillar was the juvenile form of an exceptionally rare moth known as *Ursia furtiva*.

"No one's ever seen this before," he told me. If Wagner was the first person to lay eyes on an *Ursia furtiva* caterpillar, I figured, that meant I was the second. Un-fucking-believable.

Caterpillars are to lepidoptera—butterflies and moths—what grubs are to beetles and maggots are to flies; they are larvae. Even among nature lovers, larvae tend to be unloved. For every ten butterfly fanciers, there are approximately zero caterpillar enthusiasts. The reason for this will, to most, seem obvious. The worm in the apple is usually a caterpillar.

Wagner specializes in caterpillars, or, it might be more accurate to say, is consumed by them. (They are, he suggested to me, the reason he is no longer married.) Probably he knows more about the caterpillars of the U.S. than anyone else in the country, and possibly he knows more about caterpillars in general than anyone else on the planet. When he travels, it's not uncommon for him to return home with a suitcase full of specimens. Most of these he has injected with alcohol; some, though, may remain alive, nestled in little vials of their favorite plants.

Wagner's "Caterpillars of Eastern North America," published in 2005, runs to nearly five hundred pages. It relates the life histories of roughly that many species and is considered the definitive field guide on the subject. Wagner is now thirteen years into an even more ambitious project, "Caterpillars of Western North America," which he plans to publish in four volumes.

The implicit argument of Wagner's work is that every larva matters, no matter how small, squishy, and unassuming. Each new species that he collects is a different answer to life's great conundrum: how to survive on planet Earth. Each has a unique and often startling story to tell.

"I want to write each species account so you want to read one more," he told me. "I want it to be a page-turner."

Wagner, who is sixty-six, grew up pretty much all over the place. His father, a metallurgist, worked for U.S. Steel, and the family moved whenever he was assigned to a new project—a bridge in one state, a pipeline in another. In second grade, Wagner attended three different schools. "I don't know where I'm from," he told me. At one school, in Missouri, he remembers, he was greeted by kids throwing rocks at him.

From an early age, he was interested in bugs. He collected them in an old cigar box, which moved from town to town with him. "They meant the world to me," he said. "I would go into my room at night, and I would look at them with a hand lens. There was an infinite amount of beauty and complexity there." Though his parents didn't share his interest, they abetted it. They bought him "A Field Guide to the Butterflies of North America, East of the Great Plains," which he read so often that the cover fell off.

“That book was a portal for me,” Wagner said. “I was able to see into another world, and I was fascinated by it.” A Christmas letter his father sent to a relative in 1966 describes Wagner, then in fifth grade, as interested in “anything that crawls or moves.” His father writes that he is sorry to be unable to answer Wagner’s “million and one questions per day.”

In college, at Colorado State, Wagner took classes from Howard Ensign Evans, an expert on wasps who had given up a tenured professorship at Harvard to move to the Rockies. Evans was the author of “Life on a Little-Known Planet,” a book that, by entomological standards, counted as a blockbuster. Published in 1968, it was a paean to the sorts of insects people usually regard as pests—locusts, for example, and bedbugs. (Evans dedicated the book to the lice and silverfish that shared his office.) It was also a plea for insect conservation. Americans, Evans lamented, seemed more curious about what might live on Mars than about the many uncatalogued creatures living right beneath their feet.

“Is it sensible to poke about for strange beings in space while we blindly exterminate those about us?” he asked. “It is said that not much more than half the organisms on earth have yet been described. As one who has several times discovered insects new to science in his own back yard, I can believe this.”

In graduate school, at the University of California, Berkeley, Wagner devoted himself to ghost moths. Holdovers from the days of the dinosaurs, ghost moths exhibit many curious behaviors. “When they fly, their wings flap around independently, which is a really ancient, uncoördinated mode of flight,” he explained. Males of some ghost-moth species perform a sort of aerial cha-cha as a prelude to sex. Others have specialized legs loaded with come-hither chemicals. Much remains to be learned about ghost moths, and Wagner would probably have kept right on studying them had it not been for an ecological disaster.

Back in the eighteen-sixties, in a bungled attempt to establish a silk business, a Frenchman named Étienne Léopold Trouvelot imported gypsy moths from Europe to Massachusetts. Some of Trouvelot's moths, which are now less offensively referred to as spongy moths, got loose. Their eggs hatched into spongy-moth caterpillars, which proceeded to defoliate much of New England. By the nineteen-nineties, spongy moths had pushed as far as Virginia, and their caterpillars were wreaking havoc in Shenandoah National Park. The Forest Service wanted to strike back with insecticide, but there was concern that a lot of other moths and butterflies would be killed off in the process. Researchers set up experimental plots in the Blue Ridge Mountains, sprayed some of them, and left the others alone. Then they gathered from the plots all the caterpillars they could find and sent them to Wagner at UConn's main campus, in Storrs.
"The first week, they sent six thousand caterpillars," Wagner recalled. During the next couple of weeks, more shipments arrived, until the caterpillars numbered thirteen thousand.

As anyone who has ever witnessed a spongy-moth infestation or just read Eric Carle knows, caterpillars eat voraciously. Many are picky, though, and will consume only certain plants. Wagner scrambled to staff his lepidopteran nursery. "If you could push a shopping cart, you could get a job," he recalled.

Among the thousands of larvae sent by the Forest Service were lots that Wagner didn't recognize. He called around to various colleagues, who weren't much help. At that point, there was no definitive guide to the caterpillars of eastern North America to consult. Just to have a way to refer to their charges, Wagner and his assistants started making up nicknames. A particularly colorful caterpillar became known as the Dazzler. Another, with a groove on the tip of its rearmost segment, they dubbed Plumber's Butt.

For Wagner, the experience was eye-opening. Every butterfly or moth was once a larva. And yet there was a lack of basic information on caterpillars—what they looked like, what they ate, how they got through the winter. Taxonomically speaking, they were an undiscovered country.

It was about 10 A.M. when Wagner and I left the bush by the Devils River and headed northwest, deeper into the Chihuahuan Desert. It had rained a few weeks earlier—this was the reason Wagner was making the trip—and the foliage was surprisingly green. Every so often, Wagner would spot an interesting plant and screech off the highway. He would pull out his white nylon beating sheet, which was stretched across a frame, like a kite, and thump away at the vegetation. Anything he liked the looks of went into a plastic vial, and then into the canvas collecting bag he wore slung over his shoulder. With all the stopping and starting, we didn't cover much distance, even though, when we were driving, it was often at more than ninety miles an

hour. Finally, at almost 9 P.M., we pulled into the town of Alpine, home of Sul Ross State University, where Wagner had an appointment scheduled for the following morning.

Wagner likes to say "It takes a village," by which he means that no one person, no matter how ardent, can beat every bush. During the last decade, he has built up—or, you might say, collected—an extensive network of helpers. Some have professional training in entomology; others are amateurs he has persuaded to keep an eye out for strange-looking larvae. Still others own ranches where rare species might lurk, or know people who do. Not infrequently, his collaborators FedEx him their discoveries.

I ended up meeting—and, in some cases, staying in the homes of—several members of Wagner's Texas network. They included his friends by the Devils River, Tracy and Dave Barker, both herpetologists.

"Dave's good at enlisting people," Tracy told me, referring to Wagner. "He gets to these people, and then all of a sudden they have all these jars in their kitchens."

"Dave is the one person I know who will always get back to you," Delmar Cain, a retired lawyer, told me. "Plus, he will give you fifteen jobs in the meantime—things that you need to be on the lookout for."

"Dave has contaminated everybody," a third member of the network, Michael Powell, a West Texas botanist, said, sighing.

On the way to Alpine, Wagner had told me that he was "courting" a friend of Powell's named Kelsey Wogan, by which he meant nothing romantic. (As a gift for her, he had brought along an extra beating sheet.) We met up with Wogan in the herbarium on the Sul Ross campus. She was carrying a basket filled with ziplock bags. Wagner opened the first ziplock and fished out a caterpillar.

"I've never seen anything like this before!" he exclaimed, reaching for the loupe that dangled from a cord around his neck.

To the naked eye, the caterpillar appeared gray with black splotches. Viewed at ten times magnification, it was twenty times weirder. Instead of gray, it was a dusty rose, with stripes of salmon dots that ran along its sides and met up above its many eyes. (Most caterpillars have twelve eyes, six on each side.) The black splotches were raised, like tiny hillocks, and covered in even tinier white stipples.

"This is super cool!" Wagner said. He didn't even know what genus the caterpillar belonged to, which meant that it, too, might prove to be some kind of first.

Wogan passed him another plastic bag. The caterpillar in this one was, relatively speaking, gigantic—nearly the size of a cocktail sausage. It was a velvety bronze speckled with turquoise. To me, it seemed even cooler than the first, but Wagner immediately recognized it as the caterpillar of a common butterfly, the two-tailed swallowtail, which made it scientifically uninteresting. Perhaps sensing my disappointment, he pinched the caterpillar's thorax. Two tentacles emerged from a hidden compartment, along with some goo that smelled like vomit. This, he explained, was a defensive strategy—a trick the creature used to ward off birds. Wogan seemed suitably disgusted. She handed over more bags, filled with more caterpillars.

From a caterpillar's perspective, humans are boring. The young they squeeze out of their bodies are just miniature versions of themselves, with all the limbs and appendages they'll ever have. As they mature, babies get bigger and stronger and hairier, but that's about it.

Caterpillars, for their part, are continually reinventing themselves. They emerge from tiny, jewel-like eggs and for their first meal often eat their own egg cases. Once they reach a certain size, they sprout a second head, just behind the first. They then wriggle free of their old skin, the way a diver might wriggle out of a wetsuit. (In the process, the old head drops off.) In the course of their development, they will complete this exercise three, four, in some species sixteen times, often trying out a new look along the way. The spicebush swallowtail, for example, which is found throughout the eastern U.S., emerges from its egg mottled in black and white. This color scheme allows it to pass itself off as a bird dropping. After its third molt, as a so-called fourth instar, it turns green (or brown), with two yellow-and-black spots on its head. The spots, which look uncannily like a pair of eyes, enable the swallowtail to pretend it's a snake.

After running through its allotment of instars, a caterpillar ceases to be itself and becomes a pupa. It sheds its skin one last time and develops a hardened shell. Inside this shell, its body dissolves. Then, from bundles of cells known as imaginal disks, a new body takes form. Some disks develop into legs, some wings, some genitalia, and so on. The creature that emerges retains almost nothing of its juvenile self except, weirdly, its memories.

As a way of life, this radical, whole-body transformation is ancient. It arose some three hundred and fifty million years ago, during the Carboniferous period. How, exactly, the process evolved is still debated, but it has proved wildly popular. Not only moths and butterflies undergo complete metamorphosis; so, too, do beetles, flies, wasps, fleas, and lacewings.

When we'd first set out on our collecting expedition, Wagner had issued a warning. There wasn't going to be much time on the trip for sleeping or eating. "We can do two meals a day," he had said. "But I don't think we'll ever see three." In fact, as we tore around West Texas, we hadn't skipped many meals. But Wagner, at least, was staying up later and later. The more caterpillars he collected, the longer it took to care for them.

One night in Alpine, I volunteered to help. By this point, we were five days out, and Wagner's travelling menagerie had grown to include some seventy hungry caterpillars. His plastic vials were arranged in rows on the nightstand of his hotel room. He pulled several bagfuls of leaves from the room's mini-fridge.

Any animal that eats voraciously poops voluminously. The first task of the evening involved cleaning the shit—or, more politely, frass—out of the vials, a practice Wagner referred to as "mucking the stalls." He handed me a paper plate. I was to dump the contents of a vial onto the plate, swab out the container, and then put the caterpillar back inside, along with a fresh sprig of its host plant. As we were mucking the stalls, Wagner realized that one of the caterpillars Wogan had found had gone missing. It was another cocktail-sausage-size creature, midnight black in color. We searched around on the floor for a while but couldn't find it. Then I stood up to fetch something and felt a hideous squish underfoot.

"The caterpillar gods give and they taketh away," Wagner pronounced, wiping the black gunk off the rug. He tried to console me by claiming the caterpillar had been a relatively common one.

On top of all the mucking and feeding, each addition to his collection had to be logged, with a note made of precisely where it had been found and on what plant. Then—most time-consuming of all—it had to be photographed. Moths and butterflies make handsome specimens that can retain their looks for centuries. Caterpillars, sadly, don't last. Pickled in alcohol, they become soggy and discolored; unpickled, they rot. Photographs are pretty much the only way to preserve them.

Wagner treats his subjects like so many many-legged Christy Turlingtons. He poses them on sprigs that he attaches to a little stand, which he arranges in front of a green background. Then he leans in with a huge macro lens. Wagner confessed to me that he wants his caterpillars to be hungry during a photo shoot; that way, he can catch them in what's called their resting posture. (At rest, a caterpillar colored like a twig will stick out at an angle, just as a real twig would do.) Caterpillars don't see very well; probably they can detect light and dark, but not much else. Nevertheless, Wagner likes to capture them "looking" at the camera.

“Eye contact is critical,” he told me. “People are going to connect to that.”

The night of the squish, I hung around for a while to watch Wagner shoot and reshoot that day’s finds. He was wearing his usual field uniform—jeans, sneakers, a short-sleeved button-down shirt, and a cap printed with the logo of Caterpillar, Inc. (The cap, he told me, was “tongue-in-cheek.”) He was so much bigger than his models that when I took a picture of him taking a picture of them it looked like a man photographing nothing.
Seen in Wagner’s extreme-closeup shots, the caterpillars were, once again, spectacular. One, which Wagner had found on a pine tree, was gray, with uneven dark patches that looked like shadows and made the caterpillar appear to have the texture of pine bark. Another, which he had found on an oak leaf, was dark green with a white stripe down its back that mimicked the leaf’s midrib, and light-green stripes that mimicked its veins. “I think a lot of people find insects repugnant or ugly,” Wagner told me. “I can’t see that.”

Around midnight, I decided it was time to turn in. Wagner, I learned the next morning, had stayed up for three more hours. “The only reason I go to bed is so I don’t mess up the next day,” he said.

There are roughly sixty-five hundred species of mammals, nine thousand species of amphibians, and eleven thousand species of birds. These are what people tend to think of when they picture the world’s biodiversity. But the planet’s real diversity lies mostly beneath our regard. The largest family of beetles, the Curculionidae, commonly known as weevils, contains some sixty thousand described species; another beetle family, the Tenebrionidae, comprises twenty thousand species. It is estimated that in one family of parasitic wasps, the Ichneumonidae, there are nearly a hundred thousand species, which is more than there are of vertebrates of all kinds. (Ichneumonids inject their eggs into the larvae of other insects. Darwin adduced their existence as a powerful argument against intelligent design; he could not, he wrote, imagine a “beneficent and omnipotent God” purposely creating such a fiendish creature.) There are, in fact, so many

insect species—at least two million and possibly as many as ten million—that Robert May, an Australian physicist turned theoretical ecologist, once joked, "To a good approximation, all species are insects!"

In keeping with their variety, insects play a vital role in virtually every terrestrial ecosystem. Roughly three-quarters of the world's flowering plants depend on insects for pollination. Insects are also crucial seed dispersers; many plants stud their seeds with tiny treats to entice ants to carry them off. And they're key decomposers. (When a person dies, blowflies arrive on the scene within minutes; in warm weather, blowfly maggots can eat through most of a corpse within a week.)

Legions of other creatures, meanwhile, depend on insects for food. Insectivorous mammals include hedgehogs, shrews, and most species of bats. Just about all amphibians consume insects, as do many species of reptiles and freshwater fish. Lots of birds rely on insects, particularly during breeding season: before they fledge, a clutch of young chickadees will consume as many as six thousand caterpillars. Collectively, insects transfer more energy from plants to animals than any other group. They are the solder that holds food chains together.

This vital work is, at least by *Homo sapiens*, underappreciated. To the extent that we attend to insects, usually it's to those that irk us. If there's a moral to Wagner's work, it is that, instead of arrogantly blundering along, we ought to pause and look more closely. What we'd discover is one marvel after another.

The caterpillar of the silver-spotted skipper, I learned from "Caterpillars of Eastern North America," uses an air-gun-like appendage in its anus to send its frass pellets soaring. This practice, known as "fecal firing," discombobulates parasitic wasps. The silvery blue caterpillar possesses a "nectary organ" that dispenses a sugary liquid; ants attracted to the liquid are enlisted as bodyguards. The camouflaged looper confuses potential predators by chewing off bits of plant matter, like petals, and attaching them to its back. When threatened, the catalpa sphinx caterpillar spews out green goo and thrashes around violently. The walnut sphinx caterpillar, too, is a thrasher; instead of spitting up goo, it whistles through its air holes, or spiracles. The lace-capped caterpillar is colored to look like a piece of dying vegetation; when it eats out a section of a leaf, it fills the gap with its body, in effect becoming the damage it has caused.

One day, toward the end of our collecting trip, Wagner and I pulled off the road a few miles from the Mexican border. As usual, Wagner laid out a beating sheet and started to whack at the vegetation. By this point, I was getting to be a pretty experienced whacker myself. I was also getting better at distinguishing caterpillars from the bits of plant debris that fell onto the beating

sheet Wagner had loaned me. (The key difference is that caterpillars move.) After laying into a plant called devil's claw, I found a small, unexceptional-looking green caterpillar, which, viewed under a hand lens, still appeared to me to be small and green and unexceptional. I showed it to Wagner, who immediately noticed something special about it. The caterpillar was covered in minute spines, but, he explained, it lacked the markings common to similarly spiny caterpillars from the genus *Heliothis*.

"I think your little green thing may be significant," he told me. He put it in a vial and said that he was going to send it off for genetic analysis. Depending on the results, it could get its own entry in "Caterpillars of Western North America."

Around the time that Wagner turned sixty, in 2016, he started to think about retiring and, possibly, moving out West. But then another, much bigger ecological crisis intervened—what's become known, perhaps prematurely, perhaps not, as the insect apocalypse.

The first sign of the "apocalypse" came from the city of Krefeld, in western Germany. For decades, members of the Krefeld Entomological Society had been trapping insects in protected areas near the city. Every bug they caught they weighed and preserved in bottles of alcohol.

In 2013, society members returned to two sites they had first sampled in 1989. To their surprise, the total mass of the insects they caught was just a fraction of what it had been the first time around. When they resampled other areas, the results were much the same. They passed on their data to a team of scientists, who wrote up their conclusions in a paper that ran in PLOS One in 2017. In less than thirty years, "total flying insect biomass" in the areas sampled had dropped by three-quarters, the paper said—suggesting that the entire flying-insect community had been "decimated."

Other papers filled with equally bleak statistics soon followed. A study of the Upper Mississippi River and the Western Lake Erie Basin found that the number of mayflies emerging from the two waterways had dropped by more than half just since 2012. (Mayflies can form such large swarms that they are visible on radar.) An analysis of data collected each summer in Ohio showed that butterfly sightings in the state had declined by a third in little more than two decades. Researchers working in the Hubbard Brook Experimental Forest, in New Hampshire's White Mountains, discovered that the number of beetles in the forest had fallen by more than eighty per cent since the mid-nineteen-seventies, and that some beetle families had disappeared entirely.

As the papers piled up, a counter-movement took shape. Some researchers argued that there was a bias toward doom. Studies that found no particular trend in insect numbers were less interesting than those that suggested a crisis, and therefore were less likely to get published. Other researchers pushed back. Even if insects were doing O.K. in some places, they said, the outlines of the problem were clear and the stakes too high to wait.

"If we do not take action now to address declines in insect abundance and diversity, we will very likely face problems . . . that will make many previous challenges faced by human civilization seem tame by comparison," a trio of researchers led by Matt Forister, of the University of Nevada, Reno, wrote.

From his own experience, Wagner knew that many species that used to be common had become rare. He had published a paper in 2012 titled "Moth Decline in the Northeastern United States"; it noted that several large, showy moths, like the promethea silkmoth, which had been easy to find when he arrived at UConn, in the late nineteen-eighties, had since vanished. The more data that came in the more concerned he became.

In the fall of 2019, Wagner organized a session called "Insect Decline in the Anthropocene" for the annual meeting of the Entomological Society of America, which was held that year in St. Louis. It turned out to be one of the conference's best-attended sessions. Most of the speakers, including two of the authors of the Krefeld paper, offered dire warnings; a few, though, warned against being too dire.

I first met Wagner not long after that session, at a Christmas party where I was also introduced to several giant cockroaches. The party was held in the entomology offices of the American Museum of Natural History. That evening, as we snacked on fried crickets, Wagner told me, "For the first time, I think people are really worried about ecosystem services and all the things insects do to sustain the planet."

Last month, I met up with Wagner again at the Natural History Museum. He had received a grant from the National Science Foundation to organize a five-year research program on insect decline, and the museum was hosting a conference to kick off the effort. As if to underscore the urgency of the situation, on the first day of the meeting a new paper on the status of insects appeared. The paper, by researchers at the Chinese Academy of Agricultural Sciences, found that the number of flying insects using a key migration corridor between China and the Korean Peninsula had dropped significantly in just over fifteen years, and that the losses were higher

among species that prey on other insects. It suggested that food webs were starting to break down. “Active conservation of insect communities is pivotal,” the study concluded.

Much of the conference took place in a wood-panelled room presided over by a portrait of Teddy Roosevelt. Participants included experts on, among many other groups, bees, dragonflies, katydids, and dung beetles. Wagner opened the gathering by saying he was there “because the bugs demanded that I do this.”

Some of the presentations were held over Zoom, with all the attendant technical glitches. Matt Forister talked about declining butterfly counts in California’s Central Valley and, even more worrying, at high elevations in the Sierra Nevada. Greg Lamarre, a scientist at the Smithsonian Tropical Research Institute, reported that insect populations on Panama’s Barro Colorado Island appeared to be stable. Dan Janzen, a tropical ecologist who teaches part of the year at the University of Pennsylvania, spoke from his home in northwestern Costa Rica; behind him hung plastic bags filled with what I assumed were specimens. In the sixty years that he’d been studying the region, he said, insect numbers had fallen catastrophically.

“When conservationists speak about tropical forests that have been heavily hunted, they call them ‘empty forests,’ ” he observed. “What we’re seeing is an empty forest.”

Wagner told me that the heterogeneity of the data coming in had convinced him that insects, rather than suffering from one particular thing, were suffering from everything. “If the stressors are the things we understand—such as lights, pesticides, loss of habitat, climate change, pollution, exotic species, and the industrialization of agriculture—I think that makes perfect sense,” he said. The main threat in the American West, he believes, is drought driven by warming.

“Insects are all surface area and no volume,” he explained. “So they don’t have the capacity to store water. And they’re additionally challenged, because their respiratory system differs from ours. We take in air through our mouths and deliver oxygen through our blood. But insect blood doesn’t carry oxygen. So they have to have these breathing tubes that penetrate every single cell group in their body, and that compounds their rate of water loss.” Insects endemic to dry areas must, of course, have ways of dealing with drought, or they wouldn’t exist. Some moths, for example, can wait out a dry spell underground, as pupae, in a state close to suspended animation. But even they have their limits. At a certain point, with no rain, the pupae expire. Wagner said he felt he was in a race against aridification.

“We’re going to solve this climate crisis,” he told me. “We’re going to decarbonize. But it’s going to be too late for a lot of the organisms I love.”

On the second day of the meeting, everyone put on a safety vest and hard hat and trooped over to the museum's newest addition, under construction on Columbus Avenue. The building, which is slated to open later this year, will house the Solomon Family Insectarium, where live cockroaches, beetles, and leaf-cutter ants will be on display. On the walk over, I fell into conversation with one of Wagner's former graduate students, Piotr Naskrecki, an entomologist who works in Gorongosa National Park, in Mozambique.

"Dave has been my hero and my inspiration pretty much my whole adult life," Naskrecki told me. "He has this ability to reignite my belief that what I'm doing matters. One example comes from when I was working on my Ph.D. I was doing a side project on the phylogeny of hummingbird flower mites, which live in the nostrils of hummingbirds. I showed him the results, and I kind of wanted him to tell me, 'Don't waste your time.' But instead he told me, 'This is fantastic!' "

Although it was a Saturday, the insectarium was humming with construction workers when we arrived. Giant metal flowers rose from the floor, and a twenty-foot-tall amber-colored honeycomb, made from some kind of resin, hung from the ceiling. The place was clearly designed to inspire joy and wonder in children (and in whoever might be accompanying them). But I could see from the writing on the wall that the messaging was serious. "Insects appear to be declining globally, in ways we are only beginning to understand," a newly painted placard said.

As it happened, the museum was also showing a temporary exhibit on insects, this one consisting entirely of photographs. Each image was an extreme closeup of a specimen from the museum's vast insect collection, with an emphasis on species that are endangered or already gone. During one of the breaks in the meeting, I wandered around the exhibit, which was nearly empty, though the rest of the museum was mobbed. Two boys were fiddling with the dials on a display monitor

that allowed viewers to zoom in even further on the closeups. I heard one of the kids say to the other that he wanted to see the bug's "butthole." The boys' parents exchanged knowing glances.

One of the photos showed an hourglass drone fly, blown up to the size of a Doberman. Each lens on the fly's two compound eyes was visible, as were the three ocelli on the top of its head: these "little eyes," it is thought, help the fly orient itself in space. Hourglass drone flies, the label noted, "were once common throughout much of northern North America, but they have nearly disappeared."

A second photo captured the San Joaquin Valley giant flower-loving fly in profile, with its long, pointy proboscis hanging down like a scabbard. The fly, once thought to be extinct, was rediscovered in two spots in the nineteen-nineties; then, in 2006, one of the populations was obliterated by development. Probably there are just a few hundred individuals left, in a single dune east of Bakersfield, California.

Another photo showed a Rocky Mountain locust with its hind legs extended like ski poles. Rocky Mountain locusts were once so numerous that their swarms blocked the sun. A particularly immense swarm, in 1875, was estimated to stretch over almost two hundred thousand square miles and to comprise three trillion individuals. Thirty years later, the locust was extinct. This story, from trillions to none, is a lot like that of the passenger pigeon, which also disappeared in the early twentieth century. No one knows how the locust was eliminated; probably the cause was farming. "As settlers moved into Native lands in the West, they plowed and planted over the insects' nesting areas," the photo's label said.

In total, there were photos of forty insects on display. All of them were of adults. It occurred to me that, once again, larvae were getting short shrift.

When Wagner started out in entomology, the only way to be sure what species a caterpillar belonged to was to raise it through metamorphosis and see what emerged. Even then, there were no guarantees: many moths and butterflies look a lot alike, apparently even to each other. To guard against mistakes at mating time, lepidoptera have evolved some of the most elaborate genitalia in the animal world, and to guard against mistaken I.D.s lepidopterists often had to resort to dissecting a specimen's sex organs under a microscope. (A famous story about Vladimir Nabokov, who served as the curator of lepidoptera at Harvard's Museum of Comparative Zoology in the nineteen-forties, has him announcing to a group of visitors, "Excuse me, I must go play with my genitalia.")

These days, professionals have better options than genital dissection. When Wagner wants to know the identity of a caterpillar he's caught, he euthanizes the insect by injecting it with alcohol. Then he cuts off one of its prolegs—these are the stubby appendages located behind caterpillars' six front, or "true," legs—and sends the tissue off to a lab in Ontario. From this tissue, the lab sequences a section of a gene known as cytochrome c oxidase subunit 1, or CO1.

All animals possess a copy of CO1—many copies, actually—which is critical to cellular respiration. But each species' version is slightly different from every other's, so the gene can be used as a kind of taxonomic fingerprint. (What's known as DNA bar coding usually involves an analysis of CO1.)

A few months after we returned from Texas, Wagner got word that the results for the samples he'd sent off from our trip were in. These would tell him what species the caterpillars we'd gathered had belonged to and prove that several were new to science, or, perhaps, do the opposite. Wagner spoke of "unwrapping" the results with the eagerness of a kid looking forward to Christmas. He promised to wait to look at them until we could go through them together, over Zoom. Later, he confessed to me that he had peeked at some of the data early.

The first sequence we unwrapped belonged to the "little green thing" I'd found, which Wagner had led me to believe might be "significant." The caterpillar was basically a pest species, related to a corn earworm, and not significant at all. I hadn't given the green thing much thought—in fact, I couldn't quite remember what it looked like. Nevertheless, it was a blow.

Kelsey Wogan's caterpillar, by contrast, turned out to be a real find. It was a genetic match with a very rare tan-colored moth known only from two specimens at the Smithsonian. (The moth is so rare it has never been formally described.) Wogan was probably the only person ever to have collected one of the moth's rose-colored larvae, and Wagner was the only person ever to have photographed it. "You can't do much better than that," he said.

In among the results were several more hits. The suspected *Ursia furtiva* caterpillar did, indeed, turn out to be an *Ursia furtiva*. A bright-yellow number that Wagner had collected near the Mexican border turned out to belong to another extremely rare species, *Neoilliberis arizonica;* probably it, too, was the first caterpillar of its kind ever collected. An unremarkable green specimen Wagner had found outside Alpine, the genetic analysis showed, belonged to a species new to science. Another unremarkable caterpillar—a tiny brown inchworm—represented not just a new species but possibly a new genus. There was also a surprise new species Wagner asked me not to reveal much about. This was to prevent other entomologists from trying to describe it before he had a chance to.

“You could say, ‘There was one exceptionally interesting discovery that Dave made me embargo,’ ” Wagner suggested during one of our Zoom sessions.

“The more you know, the more fun this is,” he said during another.

Wagner once told me, matter-of-factly, that he had never experienced a period of gloom or depression. Apparently, this included the time he spent going to school with kids who threw rocks at him, as well as the years he has devoted to pondering the “insect apocalypse.” During the week I spent with him in Texas, I never saw him get rattled or annoyed, even though one day he sat on (and shattered) his iPhone and another day he had to skip an elaborate expedition he’d planned because a colleague reminded him, a few hours before the deadline, that he hadn’t filed a student recommendation. At the conference at the Natural History Museum, he never seemed down, even when the presentations appeared to leave no other option. I wasn’t quite sure what to make of this. Was his optimism simply a matter of temperament, or did it have something to do with looking at life through a loupe?

“To a person attuned to smaller creatures,” Wagner’s former professor Howard Ensign Evans once wrote, “there is no corner of nature not full of excitement, not rich in unsolved problems.”

The Earth, Evans added, “is a good place to live.” ♦

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