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Scientists Spent Years on a Plan to Import this Wasp to Kill Stinkbugs.

Then it Showed Up on its Own — by Kelly Servick

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In a peach orchard down a rural road in Bridgeton, NJ, an uninvited guest has run amok. The brown marmorated stinkbug (*Halyomorpha halys*) has been gorging on the unripe fruit. The bugs have sunk their needle-sharp stylets into the peaches, creating wounds that ooze a clear, sugary goo; form corky brown blemishes; and leave the trees more vulnerable to infection.

In this orchard, managed by the Rutgers University Agricultural Research and Extension Center, the mottled, shield-shaped stinkbug is a research subject. In surrounding farms and homes, however, it's a despised invasive pest known for its indiscriminate appetite, its tendency to escape cold weather by crowding into homes—sometimes by the thousands—and the pungent, cilantro-like odor it releases when crushed. (Exterminators often recommend that homeowners vacuum up the insects instead.)

Native to Asia, the bug was first spotted in the United States in 1998; it has since reached 43 states and Washington, DC, attacking fruit trees, corn, soybeans, berries, tomatoes, and other crops. Statistics are scarce, but an industry group estimates that Mid-Atlantic apple growers alone lost $37 million to stinkbug damage in 2010.

In the peach orchard, however, another surprise invader also is on the march—and it may prove to be the stinkbug's nemesis.

Like many invasive species, the brown marmorated stinkbug has no major enemies in its new home to keep its population in check. So in 2005, entomologist Kim Hoelmer and his team at the US Department of Agriculture's (USDA's) Agricultural Research Service (ARS) in Newark, DE, turned to a strategy known as classical biological control: they traveled to Asia to find natural enemies of the stinkbug that they might release in the United States.

Fanning out to agricultural fields and botanical gardens, the team searched for the bug's tiny clusters of barrel-shaped eggs. They checked whether any had been invaded by parasitoid wasps, which inject their own eggs into the stinkbug's, leaving larvae that eat the developing bugs before chewing their way out. By far the most pervasive parasite they found was the samurai wasp (*Trissolcus japonicus*), which, despite its fearsome name, is stingerless and smaller than a sesame seed. The ARS team imported several strains of the wasp to a quarantined facility in Newark and began painstaking tests to decide whether it was a good biocontrol candidate.

Then in 2014, Hoelmer got an unexpected phone call. Elijah Talamas, a taxonomist at the Florida Department of Agriculture and Consumer Services in Gainesville, had been helping another ARS team identify native wasps parasitizing stinkbug eggs in Maryland. Talamas, an expert on Trissolcus species, had recognized that some were samurai wasps.

"It was stunning news," Hoelmer recalls. He had spent years studying the wasp in the lab to make sure that, if released, it would do its job without harming native species. But the insect was already here. Genetic tests confirmed that the wasps in Maryland hadn't escaped from any of his quarantined strains. Somehow, they had immigrated on their own.

Over the decades, a variety of uninvited biocontrol candidates have popped up on new continents, including a fungus that kills forest-stripping gypsy moths and a beetle that devours allergy-inducing ragweed. "The examples definitely are

piling up," says Donald Weber, an ARS entomologist in College Park, Maryland, whose team found the first US samurai wasps. "We've had this mindset that natural enemies would be less likely to establish than invasive pests," he says. "But sometimes, It might be fairly easy."

Those unexpected arrivals can unsettle scientists and regulators. Rules aimed at carefully controlling insect releases can seem nonsensical when the species in question is already happily spreading on its own. And the arrival of the samurai wasp has prompted a fresh look at some US regulations.

But unplanned introductions also free researchers from some of the usual constraints, allowing them to explore key questions about a biocontrol agent's impact in field experiments rather than just the lab. The team at the peach orchard, for example, is one of about a dozen US groups now releasing the samurai wasp into fields and orchards to see whether it will be an ally in fighting the exotic stinkbugs—or yet another problematic invader.

Since the samurai wasp's first US appearance in 2014, surveys have turned up at least three genetically distinct populations in areas affected by the brown marmorated stinkbug suggesting multiple introductions.

One night last May, 3600 samurai wasps streamed from mesh cages into the stinkbug-infested New Jersey orchard. A team led by Rutgers entomologist Anne Nielsen and entomologist Kevin Rice of the University of Missouri in Columbia had strung up yellow sticky cards baited with stinkbug egg clusters among the peaches and along the adjacent forest edge. They planned

A samurai wasp emerges from the brown marmorated stinkbug egg in which it hatched. Scientists hope the wasp will reduce populations of the pest in US crops. *Photo by Chris Hedstrom, Oregon Department of Agriculture*

to wait a few days, collect the cards, and count the wasps to see whether they had ventured into the orchard to pursue the peach-destroying bugs.

The insects were descendants of wasps that Nielsen first discovered in a nearby New Jersey orchard in 2017—the first find in a US agricultural crop. Maybe wasp embryos were hiding in stinkbug eggs aboard a cargo ship. An adult wasp may even have hitched a ride with an unsuspecting airline passenger. (While awaiting a flight from New York City to Russia, Talamas once watched a different parasitoid wasp species, native to the U S, land on a page of his book. "All it had to do was fly down the walkway … next stop: Russia." He trapped the hitchhiker in his contact lens case and, on arrival, preserved it in vodka.

Now that the wasps are in the US, research questions abound, Nielsen says. "In their native range, they parasitize up to 90% of brown marmorated eggs. But will their behavior be different here? Where will they congregate and forage? Will they dramatically reduce stinkbug populations? Could farmers support the wasp by adjusting their practices—for example, not spraying pesticides where the insects are most concentrated?" The chance to probe basic questions about a little-studied exotic species, Rice says, is "fabulously exciting."

For US regulators, however, the wasp's unexpected arrival poses a conundrum. "This is a good chance for us to codify policy and decide, 'How are we going to handle these circumstances?'" says Robert Pfannenstiel, an APHIS entomologist in Riverdale, Maryland, who reviews release applications. "Will we allow changes from our policies and processes that are already in place, or not?"

Studies so far suggest the samurai wasp is a promising biocontrol agent. Although in laboratory tests it has parasitized some eggs laid by native species, it has shown a strong preference for brown marmorated stinkbug eggs. Scientists can release the accidental strains in states where they've already been discovered, but for now they can't spread the wasps indiscriminately. APHIS prohibits moving exotic species that haven't been formally cleared for release into new states. (Nielsen and Rice, for example, couldn't legally perform their same experiment if they drove 4 hours north to Connecticut, where samurai wasps haven't been found—so far.)

The wasp needs to go through regulatory review, just like any other candidate, Pfannenstiel says. "The danger, in one case, of saying, 'Oh, we can tell it's not a risk,' and then releasing it [is that] there's pressure to do that repeatedly, and start making judgment calls rather than determinations based on data." Field studies of the accidental strains could speed the evaluation and help the wasp's chances of approval—or reveal new

reasons not to release it," he says. "I go into these evaluations with no preconceptions."

Hoelmer's team at ARS is still preparing a petition to APHIS to release one deliberately imported strain, which he hopes could serve as a backup if the accidentally introduced strains spread slowly. He also intends to include the accidentally introduced strains in his release petition, because their biology is so similar to that of the strain he has studied extensively. He plans to submit his petition by the end of this year, and hopes for a decision next year. For now, he says, growers and researchers in states where the wasp hasn't been detected will simply "have to wait until it crosses the border."

The researchers at work in the Rutgers orchard aren't yet endorsing the samurai wasp as a biocontrol agent. First, they'd like more evidence that it won't harm native species. "They're invasive," Rice says. "They're not in a different bucket from the stinkbugs."

The restrictions on spreading the wasp "can be frustrating, and it can seem arbitrary, but the regulations are there for a reason," Nielsen adds. Still, she says, the wasp "is likely our best hope of controlling the brown marmorated." Examining the sticky cards this summer, her team found a roughly equal distribution of wasps in the peaches and the nearby woods.

Rutgers University entomologist Anne Nielsen and graduate student Nick Avila survey a yellow sticky card for samurai wasps to track their dispersal in the peach orchard. *Photo by Dean Polk.*

That finding suggests the wasps are perfectly happy foraging for stinkbug eggs among the fruit, which bodes well for the wasps' ability to control the pests. The team plans to run a similar experiment soon to see how the wasps spread into another crop, soybeans.

Meanwhile, researchers in California have sent Talamas another surprise: a new, accidentally introduced *Trissolcus* parasitoid wasp, this one native to India and Pakistan, which emerged from the egg of another exotic stinkbug pest, *Bagrada hilaris*. "I think that these introductions are happening constantly," Talamas says, but come to light only when taxonomists bother to take a close look. He published the new finding in August 2018, in the *Journal of Hymenoptera Research*.

Such arrivals are "humbling," Weber says—a reminder of the limits that humans face in shaping their environment. "We have less control over things than we think."