Squelching Gypsy Moths

What's hot and what's not in the arsenal against the leaf eaters

By TINA ADLER

Since 1869, when Leopold Trouvelot imported gypsy moths from France to Boston in hopes of breeding a better silkworm, these insects have munched their way across the continent. In one of their record-breaking years, 1981, they defoliated almost 13 million acres; in 1993, they devoured a mere 1.8 million.

The successors of Trouvelot's moths are concentrated in an area that extends from Montreal to Virginia and west to Ohio and Michigan. Their cousins – the Asian gypsy moth – traveled as stowaways on boats from Russia to the West Coast in 1991 and from Germany to North Carolina in 1993. The Asian moths eat more voraciously than the Europeans and, because the females can fly, may spread four to five times faster, researchers warn.

Gypsy moths do a year's worth of damage in a single season. So every spring, before the caterpillars begin defoliating trees, entomologists venture out to forest plots to test their latest weapons against the critters, hoping to prevent the damage moths can do if left unchecked.

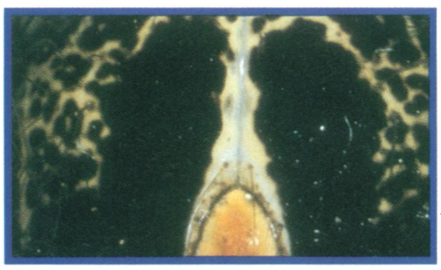
Their forays this spring may be particularly urgent. Scientists expect another big outbreak soon, though they don't know exactly when. Also, new studies suggest that Dimilin, one of the most effective pesticides against gypsy moths, does more damage to the environment than previously thought. And the Asian moths may require different controls than the French import.

Entomologists plan this spring to test an improved version of one of the moth's natural predators, the nuclear polyhedrosis virus (NPV). They will also monitor the spread of the moth's archenemy, the fungus *Entomophaga maimaiga*. Both the virus and the fungus leave most other insects alone and don't threaten forest ecosystems, researchers say.

The U.S. Forest Service uses NPV to produce Gypchek, one of two biological insecticides registered for use against the gypsy moth and the only one that doesn't harm other insects, researchers say. When a gypsy moth caterpillar ingests Gypchek, the protein enclosing the virus' active ingredients, called virions, dissolves in the insect's stomach. This sets the virions loose inside the caterpillar, where they replicate and eat it "out of house and home," says Edward M. Dougherty of the U.S. Department of Agriculture's Agricultural Research Service (ARS) in Beltsville, Md.

In terms of its environmental impact, Gypchek "wears a real white hat" says Ralph E. Webb, also of ARS in Beltsville.

In terms of its efficacy, it works as well at killing caterpillars as *Bacillus thuringiensis* (Bt), the other biological pesticide registered for use against gypsy moths, and diflubenzuron (Dimilin), a commonly used chemical insecticide, says John D. Podgwaite of the Forest Service. His laboratory in Hamden, Conn., makes Gypchek in collaboration with a USDA Animal and Plant Health Inspection Service laboratory on Cape Cod, Mass. Gypchek destroys entire populations of gypsy moths and leaves a residue to infect future generations, Webb says.



Donald Specker

But because Gypchek takes about 2 weeks to kill the caterpillar, it fails to prevent defoliation as well as other insecticides do, says Podgwaite. It's also costly. Researchers have to grow the virus in caterpillars, which "is time-, space-, and person-intensive – and it's stinky too," says Jack C. Schultz of Pennsylvania State University in University Park.

Tests from the last two springs suggest that researchers may have solved some of these problems. Though Gypchek still works poorly when sprayed from airplanes, researchers have improved its performance when applied from the ground. By adding an optical brightener called stilbene disulfonic acid to Gypchek, they have reduced the dose needed by 40 percent, Webb says.

Optical brighteners are the ingredients in detergents that, as the advertisement goes, "make your brights brighter, your whites whiter," Dougherty explains. This one protects the virus against its primary foe, ultraviolet light. It also "allows virus to get into the animal quicker," although just how it does that remains unclear, says Podgwaite.

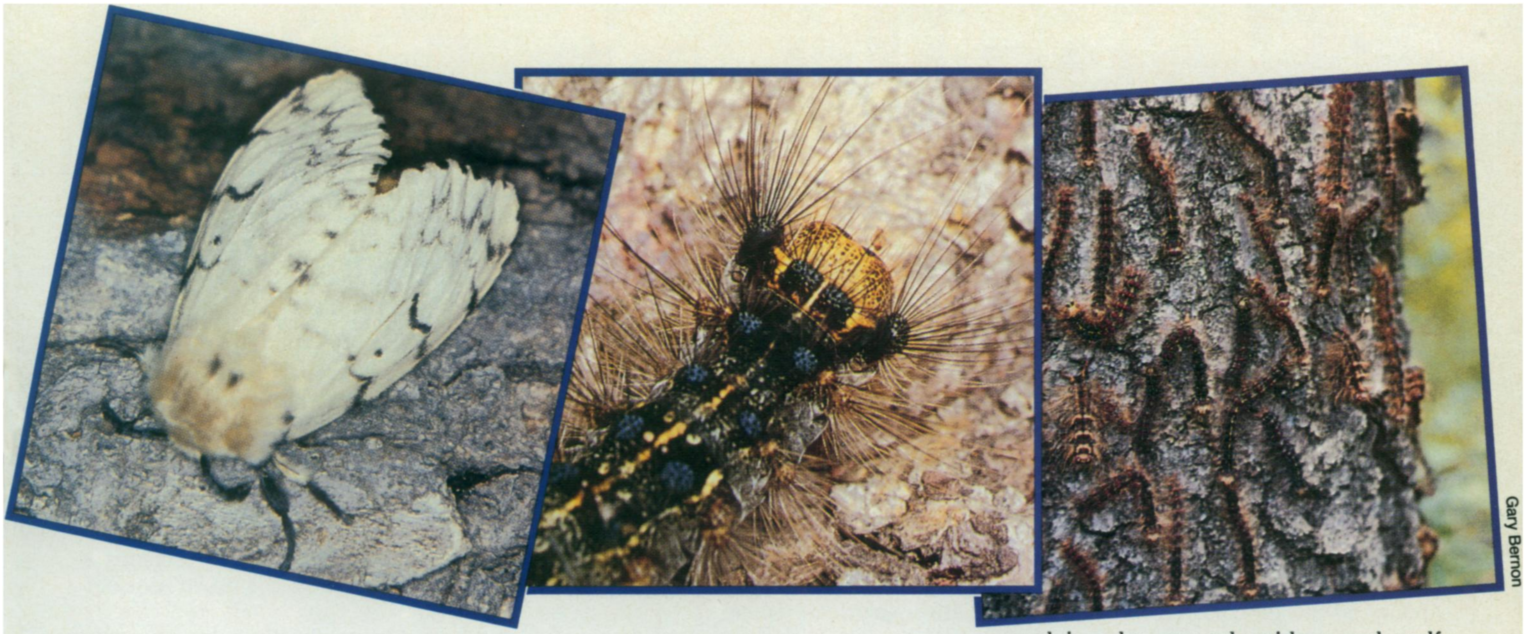
In 1992, Webb and his colleagues tested the brightener-NPV mixture on both heavily and lightly infested forest sites. The mixture, when sprayed from the ground, killed more caterpillars more quickly than the virus alone had, they report in the January JOURNAL OF ENTOMOLOGICAL SCIENCE. In fact, about 98 percent of the mature caterpillars died when exposed to the mixture, compared with only about 63 percent of those exposed to the virus alone. About 35 percent died in untreated plots, they write.

But the mixture took about a week to kill the caterpillars, so it prevented only about half the defoliation that would have occurred without any treatment, says Podgwaite. That's about twice as successful as the virus alone, but not as effective as Dimilin or Bt, he adds.

Because of such drawbacks, pesticide manufacturers have yet to produce a commercial product containing the virus. In fact, American Cyanamid of Princeton, N.J., recently ended a 2½-year collaborative effort with USDA on the virus, says Mark Galley, a company official.

"We made a lot of progress" on the brightener, Galley says, but decided that "the continued investment that [the virus] would need would not be returned." The company applied to the Environmental Protection Agency 9 months ago to test the effects of the brightener in *Baculoviruses* in general, he says. Researchers at American Cyanamid and elsewhere are also trying to manipulate the DNA of *Baculoviruses* to enable them to infect more species, he says.

Tannin in trees may limit the virus' success, according to Schultz and Heidi Appel, also of Penn State. Their studies show that as caterpillars defoliate a tree, the quantity and structure of the tannin in the leaves changes, becoming more deadly to the virus. In addition, by chewing the leaves, the caterpillars oxidize the tannin, making it more active. Schultz



Gypsy moth eggs hatch in April, and the larvae are blown onto leaves, where they feed. But sometimes, as in the last picture, a fungus feeds on them.

Gary Bernon

speculates that the tannin weakens the virus' ability to recognize and invade the caterpillar's stomach lining. So to prevent the tannin from oxidizing, he and his colleagues are adding antioxidants to the virus.

The *Entomophaga maimaiga* fungus, another natural enemy of the gypsy moth, has proved a surprisingly strong ally, entomologists say.

"It has forced us into rethinking what to expect from the gypsy moth," says Paul W. Schaefer, who studies gypsy-moth-killing beetles for the ARS in Newark, Del.

Researchers first released the fungus' spores at forest sites in 1989. The spores infected about 85 percent of the caterpillars and spread rapidly (SN: 8/4/90, p.77). Since then, the fungus has made "a huge leap," says Ann E. Hajek of the Boyce Thompson Institute for Plant Research in Ithaca, N.Y.

In 1991 and 1992, she and her colleagues released spores in forests in Virginia, West Virginia, and Pennsylvania. "The fungus caused really high [rates] of infection," she says, and the moth populations took a nosedive. "It won't prevent outbreaks, but it's quite possible it will keep the populations of moths down," she says.

The fungus spreads in part by means of its airborne spores, which it releases while residing in caterpillar cadavers, she says. These spores can't last the winter, but they float through the air and infect other caterpillars that same season. While in the cadavers, the fungus produces resting spores that wash into the soil. These do survive the winter and infect more caterpillars the following spring, Hajek says.

This naturally occurring insecticide may not deserve the environmental white hat, however. Laboratory studies suggest it may kill other moths as well, Hajek reported at a USDA conference in January. She and her colleagues plan field studies this spring to study its effects on nontarget organisms.

One popular gypsy moth killer, Dimilin, also destroys insects vital to the health of the forest ecosystem. Dimilin "is the cheapest and most efficacious way to kill gypsy moths," says Webb. But the chemical has also "become the bad boy of pesticides because of its nontarget effects," Podgwaite says.

EPA registered Dimilin for use against the moth in forests 2 decades ago. However, most research on its nontarget effects consisted of laboratory studies, write Bradley E. Sample and his colleagues at West Virginia University (WVU) in Morgantown in the March/April 1993 CANADIAN ENTOMOLOGIST.

Recently, researchers from WVU looked at the effects of spraying Dimilin in the forest. They found that, of all the arthropods in the tree canopy, the macrolepidoptera larvae – which include butterflies and big moths – suffer the greatest losses. Moreover, while some populations of butterflies and large moths rebounded within a year of the insecticide application, both the diversity and density of different species remains low, reported WVU entomologist Linda Butler at the USDA conference in January. These arthropods play a critical role in the forest ecosystem as food for bats and birds.

About 40 percent of the Dimilin, on average, remains on leaves when they fall, writes Mary J. Wimmer in a summary of the WVU group's findings. In addition, it stays for at least 54 days on leaves that fall into streams. This persistence may explain why ground spiders and wolf spiders "are definitely, statistically not there" a year after the Dimilin applications, says Tim Christiansen of WVU.

"We think spiders are [still absent] because [Dimilin] is still on the leaves – the evidence really points to that," he says. These spiders feed on many other insects, so they help control the forest insect populations.

The West Virginia researchers are analyzing soil samples to see how Dimilin moves into the ground litter and degrades. This spring, they plan to begin a 9-year study of the insecticide's effects on the forest ecosystem.

Phil Hutton, product manager for microbial and biochemical insecticides at EPA, says he has not yet seen the WVU data. But he notes that earlier studies also found that Dimilin kills more butterflies, moths, and other insects "than people thought when they first registered it." Also, "it is incredibly toxic to aquatic invertebrates." Compared with the alternatives, however, Dimilin looks quite safe, he argues.

Finding environmentally friendly ways and means of killing gypsy moths still presents a formidable challenge to entomologists. But on one front they may be ahead: differentiating the Asian from the European moths.

As adults, the moths appear almost identical, but as caterpillars, their head capsules give them away, says William E. Wallner of the Forest Service in Hamden, Conn. He and his colleagues used color imaging of the head capsules to differentiate the two – a quicker, cheaper approach than the DNA analysis required to identify the adult moths, he reports in an upcoming ENVIRONMENTAL ENTOMOLOGY.

Knowing who's who will help researchers target the type of control they use – one more advance in the 125-year quest to control gypsy moths. □