Revenge of the "Nozzleheads"

Insect pheromones, once hyped as a panacea, have been quietly proving their efficacy; but federal regulation, the pesticide industry, and the very nature of the delicate chemicals themselves still stand in the way of their widespread use

Boston, Massachusetts

It was as if an ingenious chemist had discovered a pheromone for attracting entomologists and had misted the air in the Back Bay Hilton with the overpowering substance, for they were massed ten deep at the open bar in the Washington Room, the aggregation so dense it was difficult to dig a business card out of one's pocket. Japanese executives from Mitsubishi were there. So were Germans from the megaconglomerate BASF, along with corporate, academic, and government contingents of Swiss, French, Australians, Canadians, Dutch, and English.

The polyglot throng had come to hear about pheromones, the discrete chemicals that insects use to communicate with one another, alerting their kind to the presence of enemies, food, or willing mates. For 3 days, several hundred spectators sat through 16 hours of presentations in which entomologists detailed how the use of pheromones to trap or trick insects was as effective as classical pesticides for controlling a variety of insects.*

There was something nostalgic about it all. In recent years, the fortunes of these delicate chemicals have come and gone and come back again. After dozens of pheromones were discovered and synthesized in the 1970s, the compounds were hailed as a panacea for agricultural pests. But it was not to be so.

"In the early days, everybody was enthusiastic. I mean, oh boy, pheromones were going to save the world! There was a lot of promotion. A lot of hype. A lot of smoke," says Richard Ridgway of the U.S. Department of Agriculture (USDA) Insect Chemical Ecology Laboratory in Beltsville, Maryland.

"It was the times," explains Wendell Snow of the USDA's Southeastern Fruit and Tree Nut Research Laboratory in Byron, Georgia. "They were trying to move too far too fast, just plowing ahead whether they knew what they were doing or not."

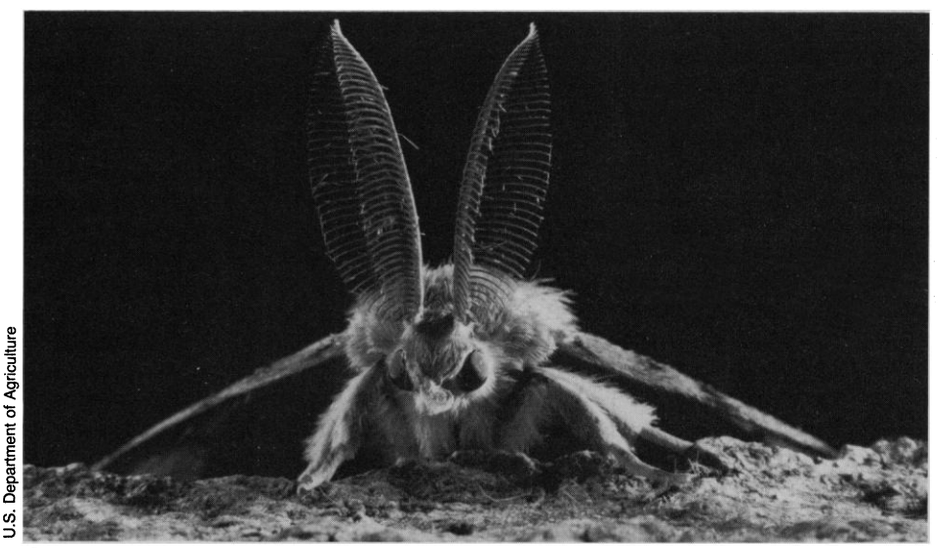
The enthusiasm faded in the early 1980s, when it was realized that the promise of pheromones was overblown and that the nascent technology was oversold. Several companies that had touted pheromones went belly up. The credibility of the fledgling pheromone industry subsequently ebbed. Growers, who were always a bit uneasy about the new method because it did not actually kill insects, became downright hostile. Says Snow: "There was great distrust."

The situation was so dismal that according to Ridgway, leading researchers like Robert Silverstein, a sort of founding father of pheromone work at the State University of New York in Syracuse, and James Tumlinson, the USDA researcher who unraveled the chemistry of the boll weevil's sexual attractant, feared that pheromones would never make it in the practical world.

So perhaps it came as some surprise even to the members of the audience that a number of their peers have found niches where pheromones control insect pests very well indeed. In the San Joaquin Valley of California, for example, cherry tomato plots were treated with a pheromone that disrupts mating between tomato pinworm moths. Peak infestation during the long growing season was less than 3%. On the control fields sprayed with insecticides, infestation reached 33%, says Manuel Jimenez, farm adviser for the University of California's Cooperative Extension Service in Visalia, California. On 200,000 acres of cotton fields in the southeastern United States the use of pheromone in traps for detecting and suppressing boll weevils resulted in a 50 to 70% reduction in the use of insecticides, according to Ridgway. Encouraging reports of pheromones being used as mating disruptants or in mass trappings were reported for such varied pests as bark beetles in Canada, peach tree borers in Georgia, oriental fruit moths in Australia, rice stem borers in Japan, and pink bollworms in Africa. According to May Inscoe of the USDA's Agricultural Research Service in Beltsville, Maryland, researchers have identified sexual attractant or aggregation pheromones for 436 insect species. About 250 of these are sold commercially by about 50 companies worldwide.

Even the corporate representatives of the big chemical companies agreed that pheromones have a future. At the very least, says D. V. Allemann of CIBA-GEIGY Corporation in Greensboro, North Carolina, pheromones should be used to make insecticides more effective, thereby decreasing the toxic load on the environment. This is bold talk for a group often referred to as "nozzleheads" by entomologists more sympathetic to the organisms they study.

Perhaps it is ironic then that problems now facing the pheromone industry are those caused by the very nature of the



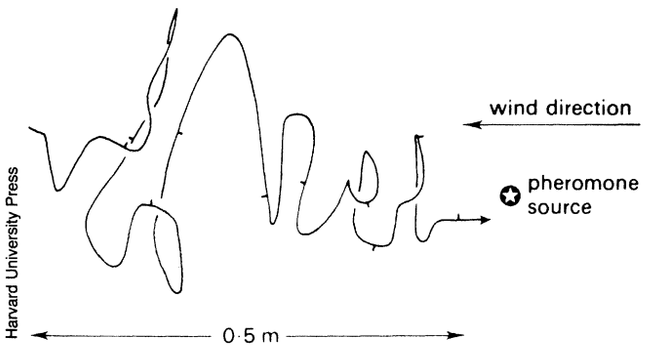
U.S. Department of Agriculture

On the prowl. *The feathery antennae of the male gypsy moth are sensitive to the highly specific pheromone emitted by the female.*

*"Practical Applications of Pheromones and Attractants," symposia held 30 November through 2 December at the annual meeting of the Entomological Society of America in Boston, Massachusetts.

Zeroing in

Track of male moth flying toward a source of female pheromone in a wind tunnel. Marks on track at 1-second intervals. [*Source:* The Insects *by R. F. Chapman*]



chemicals themselves. For one thing, the government does not really know what to make of pheromones. Federal regulators seem confused. On one side, the Environmental Protection Agency (EPA) has stated repeatedly that it considers pheromones preferable to traditional insecticides. After all, here is a biological control agent that is relatively nontoxic, species-specific, and occurs in nature. There is nothing genetically engineered about pheromones. Indeed, pheromones are often present in great concentration in nature. "Their use should be encouraged," says Edwin Tinsworth, director of the registration division at EPA. In a 1987 report, a National Academy of Sciences briefing panel chimes in: "Biological control can and should become the primary method used in the United States to ensure the health and productivity of important plant and animal species." Tinsworth noted that EPA has accelerated its review process for pheromones and has awarded pheromones a "priority" rating over classical insecticides. Unfortunately, Tinsworth admits "priority" is a hollow word at EPA. Work overloads caused by tight budgets still delay the registration process for months.

Part of the problem also comes from EPA's mind-set. The agency considers pheromones to be pesticides. The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) defines a pesticide as " . . . any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest." Given the act's broad language, "clearly pheromones are pesticides," says Tinsworth. Indeed, under FIFRA the agency could consider manatees as herbicides, mongooses as rodenticides, and goldfish as insecticides, if it wanted to.

"There is a great deal of rhetoric from the regulatory agency about the need to use these new methods. . . . But it is extremely difficult to get the agency to jump in behind us," says Timothy Dennehy of Cornell University's New York State Agriculture Experiment Station in Geneva, New York. The research in Geneva is a case in point.

The pretty rolling hills of upstate New York produce Concord grapes for wine, juice, jelly, and jam. They also provide a wonderful habitat for *Endopiza viteana*, the grape berry moth, whose larvae feed on the berries. The grape berry moth is an ideal candidate for control by pheromones. First, it is an expensive and relentless pest, yet it is the only insect that continuously attacks vineyards, making a species-specific control agent especially attractive. Also, the vineyards of New York are small and surround dwellings where one might not want to dump tons of pesticides.

Like many species of moth, *Endopiza viteana* females have a gland located at the end of the abdomen. When they are ready to mate, the female moths alight on a branch, expose the glandular pouch to the evening air, and secrete a few microdrops of pheromone which travels on the wind. When a male grape berry moth downwind detects the pheromone plume, he searches for his potential mate by flying back and forth upwind.

According to Ring Cardé of the University of Massachusetts in Amherst, the preponderance of sexual attractant pheromones for moths are acetates, alcohols, and aldehydes with an even number carbons in chains containing 10 to 18 atoms. A blend of several pheromones creates a distinct perfume for each species. The pheromone for the grape berry moth was discovered by Wendell Roelofs at Cornell's research station in Geneva. It is actually a blend of two: (Z)-9 dodecenyl acetate and (Z)-11 tetradecenyl acetate.


Scentry, Inc.

Low tech. *In the San Joaquin Valley of California, all it takes is a stick to apply pheromone-filled filaments to the stakes supporting cherry tomato plants.*

Since 1972, Roelofs and his colleagues have been placing the pheromone in vineyards and comparing its efficacy to that of traditional pesticides. One of the great difficulties has been to find an effective way to release the substance over time. All manner of dispensers have been tried: rubber septa, hollow fibers, microcapsules, and planchets. In the most recent field trials, which began in 1985, the Cornell team has been using hollow polyethylene tubes manufactured by the Shin-Etsu Chemical Company of Tokyo, Japan. The tubes are called "ropes" or "ties" and resemble the twists used to close plastic garbage bags. At the beginning of the growing season, when farmers go into their fields to tie up the vines, they bring along the pheromone ties and twist them around the wires supporting the plants.

At first, the Cornell team placed as many as 9000 ties per hectare. By 1987, they realized that they could get away with far fewer, some 500 per hectare. Apparently, this releases enough pheromone into the air to confuse the hapless males. Exactly what happens in the vineyards is still something of a mystery. Are the males frantically flying about till they drop from exhaustion? Or are they sitting someplace in a dazed state? Tracking the males is not easy task. As Dennehy points out: "We're not talking about B-52s." It is safe enough to say that "the males are trying to find females in a fog of the very same substance that males use to orient to females," says Dennehy. Successful matings plummet.

The results have been excellent. Grape clusters with more than 2% damage are unacceptable to the wine and juice industry, yet damage levels of 20% on heavily infested fields treated with insecticides are not unusual. In the recent trials in Geneva, the fields treated with pheromone had damage below 1%. On the two control fields treated with the insecticide carbaryl, damage was 18% and 2.5%, reports Dennehy. Even on fields with tremendous infestations, the pheromone worked almost as well as four applications of pesticide.

Are pheromones cost competitive? That is hard to say. Traditionally, Cornell recommends that growers apply three applications of insecticides to their vineyards annually. Dennehy says that if pheromone manufacturers deliver their product at below $30 an acre, they will be competitive. But as Dennehy notes, "Pheromone manufacturers are just as cagey as toxic chemical manufacturers. They want to know how much the

growers are spending on insecticides, and then they'll come in just below that figure."

The reason that the cost of pheromone for grape berry moth is still an academic question is because the Cornell group has had difficulty obtaining an "Experimental Use Permit" from the government, the first and largest hurdle on the road to getting full registration for a pheromone product from EPA. Particularly galling to individual investigators and the small companies they often collaborate with is the fact that it is almost as cumbersome to obtain an experimental use permit as it is to register the pheromone with EPA as a pesticide. And chasing a permit can be a lengthy and expensive process. "Mind-boggling bureaucratic mumbo jumbo," according to one entomologist. Unless a researcher can justify waiving much of the data, the EPA requires detailed information on the pheromone's toxicology, residue chemistry, possible exposure to humans and the environment, and ecological effects.

If the pheromone is going to be used on food crops, the researcher must prove that the pheromone has a limited toxicity and no adverse effects on humans. Without such a "temporary tolerance" permit, the crops must be destroyed. In Geneva, Roelofs and his colleagues have been destroying grapes for years. "At $1000 per acre for grapes, you can very clearly see why we haven't done tests on 80 acres," says Dennehy. "It's crazy," adds Roelofs. "We're destroying grapes that were protected by a completely natural nontoxic substance made by moths."

Charles O'Connor, a Washington D.C. attorney who consults for the pheromone industry, estimates that obtaining an experimental use permit can take as long as a year and as much as $300,000. "The upfront costs of data generation are prohibitive," says O'Connor. And the time factor is crucial. Some moths, for example, are on the wing for only a few nights a year. If researchers miss the reproductive window, they must wait another year to run the experiment.

In its defense, the EPA says that it waives much of the information. "The data requirements are really quite minimal," says Herbert Harrison, chief of insecticides and rodenticides for EPA. Unfortunately, though, it is difficult for researchers to know what will or will not be waived until they actually submit their applications for permits. "It's a crap shoot," says one entomologist currently in the regulatory loop. Researchers like Roelofs would like to see EPA grant "class action" registration for all related pheromones. He would also like to see data requirements slimmed down, especially for experimental use permits for researchers. Harrison says that "at some point we may give pheromones broad exemption. But it's dangerous to do that. We may eventually find one that's toxic. If we don't get any scientific information, we might never know."

Even without government regulations, pheromones may prove to be almost too benign for heavy-handed agriculture. Growers, for instance, like to see dead bugs. "It's tough to get farmers off the pesticide treadmill," says Jack Jenkins of Scentry Incorporated of Buckeye, Arizona. The big chemical companies like to sell pesticides that have broad applications. "We all know how to replace an old chemical with a new chemical, but not how to replace an old chemical with a pheromone," says Kurt Nabholz of Sandoz in Basel, Switzerland.

Yet in a world where insects are becoming increasingly resistant to traditional pesticides, the environment increasingly burdened by the toxic load, and the public more concerned about such things as contaminated ground water, pheromones, however imperfect, appear to have a role to play. Says Ridgway: "It finally looks like pheromones are here to stay." ■ **WILLIAM BOOTH**

Details of 1957 British Nuclear Accident Withheld to Avoid Endangering U.S. Ties

British Prime Minister Harold Macmillan withheld publication of details of the world's first major nuclear accident, a fire in 1957 at a plutonium separation facility, in order to encourage the United States to continue to share its nuclear secrets with Britain, according to Cabinet papers released in London last week.

The fire took place at a plant at Windscale, on Britain's northwest coast, in a gas-cooled reactor used to produce the fuel for nuclear weapons. Over 20,000 curies of iodine were released into the atmosphere. In comparison, only 30 curies escaped during the nuclear accident at Three Mile Island.

A detailed inquiry into the accident revealed that the fire, which burned for a considerable period of time before it was detected, was the result both of major design faults and lack of experience among technical staff.

However, when the report was presented to Macmillan, the Conservative Prime Minister, he instructed that key passages be deleted prior to its publication—even though it was generally accepted that there were no military secrets involved. The report has now been published under the ruling that government documents in Britain can be made available after an interval of 30 years, unless defense secrets are involved.

"When the report was done, we in the authority—with the agreement of the Ministry of Defense—agreed that there would not be any real security objections to publishing it, and we recommended to the PM [Prime Minister] that it should be published," Lord Plowden, then the chairman of the Atomic Energy Authority, said in an interview last week with the British Broadcasting Corporation. "I went to see the Prime Minister, who said he felt that to publish the report in full would strengthen the hands of those opposed to a liberalization of the Macmahon Act in the U.S., who would claim that the British did not hold on to information but publish it so that people can calculate things from it," said Plowden. "This was an entirely political judgment; Macmillan felt we should modify the publication, and this was done."

Plowden said that the accident had "all the hallmarks of an industry in a hurry" but added that one should not judge what happened 30 years ago in the light of what we know now.

"Atomic energy was a completely new industry. We were under pressure, firstly to get weapons made as quickly as possible because of the fear that there might be an invasion from Russia. Also we wanted to be on equality with the U.S. as one of the countries that did have atomic weapons. And there was also great pressure put on the atomic energy authority to develop a nuclear power program. With hindsight one would probably have gone more slowly."

John Cunningham, a member of Parliament whose constituency includes the Windscale plant (recently redeveloped under the name of the Sellafield reprocessing plant), said it remained important to ensure that no information had been withheld about the accident. "One of the most important lessons of the publication of this information is that it will give a major and much-needed boost to the campaign for a Freedom of Information Act in Britain," he said.

Ironically, some British scientists argue that the Windscale fire could have been prevented if the United States had earlier been prepared to share more of its information with Britain about the behavior of nuclear fuels, and not held back from sharing this information for reasons of national security. ■ **DAVID DICKSON**