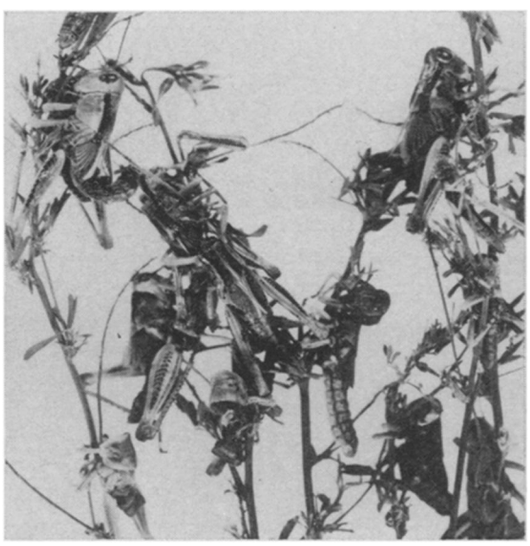
More ways than one to kill a bug

Insect viruses, if they are approved for use, may prove a successful alternative to chemical pesticides

by Kendrick Frazier

Photos: USDA

Corn earworm at his ruinous work.



Grasshoppers killed by virus in test.

Nobody expects that chemical pesticides will ever disappear completely from man's insect-hunting arsenal. Their effectiveness, utility and economy have been proven over the years, and the protection of food crops and control of disease-carrying organisms are too important to consider abandoning the most effective weapon against them.

But mounting displeasure with the harmful effects of pesticide residues (SN: 5/3, p. 423) has sparked intense interest in alternative methods of insect control: sterilization of male insects, hormones, stringent quarantines, introduction of predatory insects and burning of cotton and cornstalks after harvest, among others.

But an area of research that excites many agricultural scientists concerned with the problem involves still another method: microbial pesticides, the use of living microorganisms—primarily bacteria and viruses—to kill the unwanted insects. One strain of bacteria, *Bacillus thuringiensis* (SN: 7/12, p. 30), has been in commercial use since 1960 and proved successful in controlling the cabbage looper in California and Arizona. But many insect pathologists believe that the viruses hold the most promise.

Viruses are highly specific. In contrast to the broad-spectrum chemical pesticides, a strain of virus will kill just one species of insect. It will harm no other form of life. "It's as though you had Dillinger in a crowd of people," says Dr. A. M. Heimpel of the U.S. Department of Agriculture. "You could get him with a tommy gun and also kill everybody else. Or you could use a single shot from a high-powered rifle to eliminate just him. This is what the viruses do—kill just one species of insect.

"We have reached the threshold of a new era in insect control," he says. "I think we will no longer have to create invertebrate deserts in our fields by the use of noxious chemical agents." Principal insect pathologist in the Agricultural Research Service's Entomology Research Division, Dr. Heimpel has been studying insect viruses for years. Recently he has been spearheading the drive to clear the way for their eventual use as commercial pesticides.

Insect viruses, just like human viruses, are nothing new. They have been around for millions of years. They exist widely in nature and, unlike chemical pesticides, are a normal part of the microbiota in the environment. In fact, large numbers of insects are frequently killed by natural outbreaks of viral insect diseases.

One of the most dramatic examples occurred more than 30 years ago. Sometime before 1930 the European spruce sawfly was introduced into eastern Canada. It quickly spread through New Brunswick and Newfoundland, destroying 3,000 square miles of standing timber in Canada alone. Apparently the specific virus that had controlled the insect in Europe had not been brought with it across the Atlantic.

Then, in the mid-30's, the virus was accidentally introduced into the northeastern United States. In three years practically no sign of the insect was left; damage virtually ceased.

Another major case involved the intentional introduction of the specific virus for the European pine sawfly, another pest imported earlier to North America without its natural viral enemy. In 1949, it was destroying pine plantations and tree nurseries in southern Ontario, Quebec and the northeastern United States. The sawfly virus was sent to Canada and allowed to propagate. By 1953 the insect was under control.

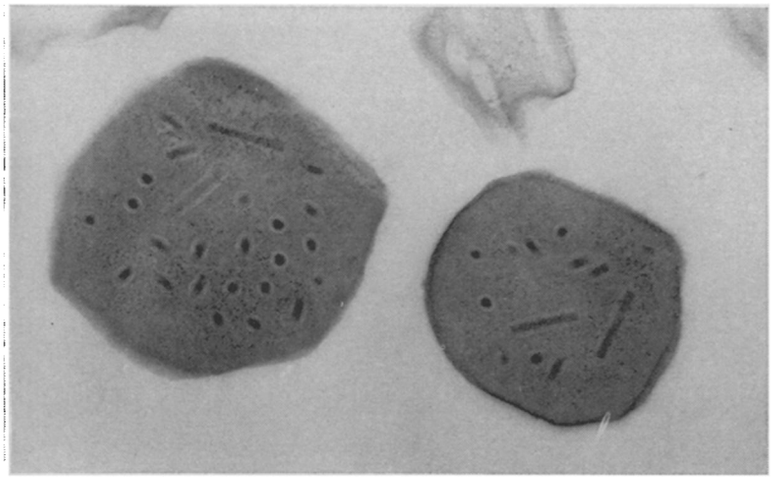
Some 280 viruses have been isolated in insects. The most promising kinds are called the nuclear polyhedrosis viruses. These rod-shaped organisms are enclosed in a protective, many-sided mass of protein that allows them to survive for years in nature.

But when ingested by the insect, the coating is dissolved in the alkaline insect gut; the virus penetrates the cells of the insects, taking over their metabolism and eventually destroying them.

This process occurs regularly in nature. Essentially the only change insect pathologists are proposing is that the viruses be prepared under controlled conditions and then distributed evenly over crops at an early enough time to catch the insect in its vulnerable youth, and in heavy enough doses to provide general control. Any conventional application method—such as spraying—can be used.

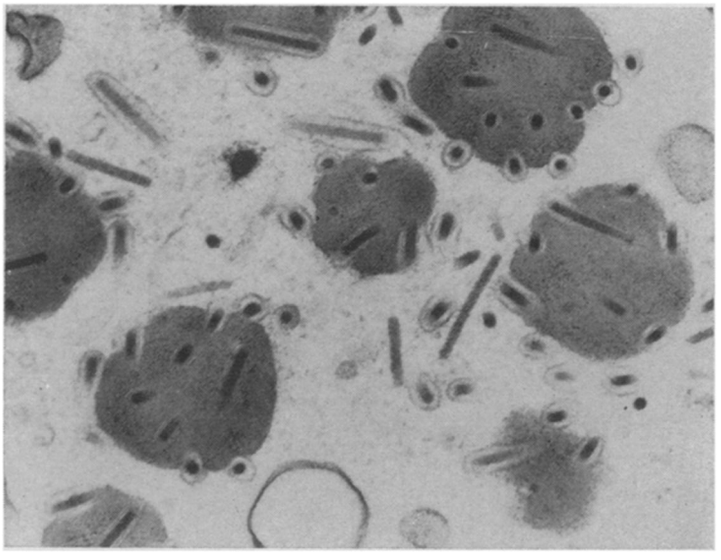
However since timing will be so crucial, there will have to be more attention given to educating the farmer in the product's use than with chemical pesticides.

Insects shown in tests to be susceptible to control by viruses include the

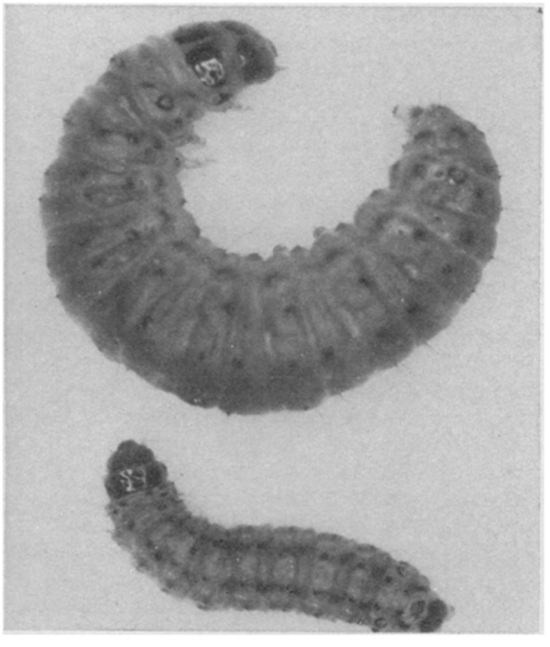


Rod-shaped viruses embedded in the polyhedral protein.

Heimpel: "Threshold of a new era."



Section of Heliothis zea cell nucleus as viruses begin embedding.



Healthy and viral-infected larvae.

pine processionary moth, the imported cabbageworm, the cabbageworm, the cabbage looper, the cotton leafworm, the bollworm and the great basin tent caterpillar. There are others.

Still, not a single viral pesticide is in commercial use in the United States.

For a while the major problem seemed to be in producing enough viruses for widespread use. But research has developed artificial media for nourishing many species of insects. They can be reared in nearly any quantity desired, and therefore the viruses they carry can also be produced in vast quantities.

Now the major block concerns proof of safety. "The situation is far from simple," says Lester Ramsey of the U.S. Food and Drug Administration. "There are many questions that we need definite proof about, such as any possible pathogenicity to other animals."

For more than a year, the FDA has been considering separate petitions from two companies for go-ahead to put a viral pesticide into use. Both applications are for products using the polyhedrosis virus that infects the corn earworm, *Heliothis zea,* also known as the cotton bollworm. It is the nation's number one insect pest. If approved, the virus would be the first ever used commercially as a pesticide in the United States.

Agriculture and industry people are sympathetic to FDA's hesitancy.

"This is the first time that anyone has ever asked the FDA to approve a virus," notes Dr. Heimpel. "They are being very cautious, as they should be. Their concern for the public interest is exemplary."

"Still," notes Dr. J. MacBain Cameron, an insect pathologist with the Canada Department of Fisheries and Forestry, "there is no known case of serious effects to a vertebrate from an insect pathogen."

Dr. Heimpel, who has been performing many of the tests, agrees. "Five years of experiments have shown that the insect viruses have absolutely no ill effect on any other living form, plant or animal."

Heliothis zea virus has been administered to test animals by inhalation, intravenous injections, cerebral injections and ingestion. Mice, guinea pigs, oysters, shrimp, rabbits, quail, mallards and trout, are among the animals that have been given doses without any effect.

That leaves humans.

Humans can't avoid insect viruses. They are present everywhere. The cabbage-looper virus is present on most green vegetables used in salads and eaten raw. So the record of man's association with them is long; no adverse effects are known.

Still, direct proof is wanted. A few years ago at the ARS research center in Beltsville, Md., 10 men and women volunteers were given one capsule a day containing a heavy concentration of

. . . viral pesticides

live *Heliothis zea* virus. During the five-day period it was estimated that each person consumed 5.82 billion polyhedra. This is enough to control the insect on 0.01 acre of cotton. Its equivalent in cabbage-looper virus would free 5,000 heads of cabbage from that insect.

Detailed examination detected no effects.

"I was one of the volunteers in that test," says Dr. Heimpel. "And I'm here talking just as vociferously as ever."

Even the FDA doesn't suspect the insect virus is harmful. It just wants additional positive proof that it isn't.

"This is a precedent-setting case," says FDA's Ramsey. "We want to be very, very careful we do the right thing."

As a result, in the last several months the FDA has requested additional evidence of safety to humans be supplied by the two companies involved—the International Minerals & Chemical Corp., Chicago, and Nutrilite Products Inc., of Lakeview, Calif.

"Certain key portions of the data are missing," says William Stokes of the petitions control branch of FDA's Bureau of Science. "We are asking the companies to supply it through further tests on animals.

"This particular virus has been handled by many people for 30 or 40 years," he says. "As far as I know there is no incidence of damage. There is no positive evidence to my knowledge that it is unsafe. But we have to have positive scientific evidence of this safety."

The outlook seems to be good.

"It is my personal opinion that these tests will show that the viruses are safe and that the authorization will be issued," says Stokes.

Dr. Heimpel expresses some concern whether the two companies can afford further tests. R. F. Anderson of IMC says his company has spent more than $2 million on viral pesticide work over a five-year period. But if the companies can budget no more funds for the tests, Dr. Heimpel says he would see whether the USDA might be able to provide grants for the work.

"FDA's request is not unreasonable," he says. "Only a couple more specific requirements still need to be fulfilled."

And what after that? Insect pathologists think they might be able to develop specific viruses against each of at least 10 of the major insect pests.

Then man would have available, not a universal panacea, but at least one additional, highly sophisticated, extremely selective weapon in his arsenal for a coordinated chemical and biological war on his insect enemies. □