Do plants control insect mating?

Wichmann and Hendry extract oak leaf roller moth pheromone from oak leaves.

Pheromones, the sex attractants of female insects, have drawn considerable scientific attention in recent years. They look promising as natural insecticides that do not endanger the environment. Field tests are under way to see whether the sex attractants of the gypsy moth, codling moth, bark beetle and other insects can be used to trap or confuse male insects (SN: 7/21/73, p. 40).

The origin of sex attractants, however, has been obscure. Now research conducted by a team of Pennsylvania chemical ecologists suggests that sex attractants are not made by female insects, as is commonly believed, but are taken from plants and stored by female insects.

This revolutionary idea, that insects can take chemicals from plants for their own reproductive purposes, could alter current efforts to exploit sex attractants as pesticides. It could also change insect classification, offer new insights into insect evolution and tie in with research on mammals and plants.

The investigators are Lawrence Hendry, Joseph Wichmann, David Hindenlang, Mary Elizabeth Anderson and Ralph Mumma of Pennsylvania State University. Their work has been submitted to SCIENCE. They will also present it to the American Chemical Society in Houston in December.

The oak leaf roller moth has seriously damaged oak forests in the northeastern United States. Hendry and his team decided to zero in on the sex attractants of the moth and try to harness the attractants as pest controls. They first identified 21 chemical compounds in the adult female moth. All of the compounds, known as tetradecenyl acetates, turned on male moths in the laboratory. Seventeen of the compounds attracted wild male moths when used in field traps. So these compounds were obviously the sex attractants of the moth.

But during the field tests, something unexpected happened. Male moths went for the traps, but they also flew to nearby oak trees and tried to copulate with the oak leaves. The investigators wondered whether the oak leaves might be the source of the insects' sex attractants. They decided to find out.

They collected oak leaves, ground them up, separated out their chemical compounds and identified them. Then they analyzed the chemical compounds in wild female and male moths, in wild moth larvae and eggs, and in female moths raised in the lab on diets of alfalfa and wheat germ rather than on oak leaves. They found that the compounds in the oak leaves were identical to the sex attractants in the wild moths. The attractants were present in the wild female moths and wild larvae in large amounts, and in the wild male moths and wild eggs in much smaller amounts. However the female moths raised on other diets than oak leaves did not contain the sex attractants, nor did they attract wild male moths.

These results suggest that sex attractants are nothing other than compounds that insect larvae absorb from the plants they eat. As the female larvae become adults, they retain the compounds in large amounts. They probably have a unique mechanism for storing these precious chemicals that ultimately reside in the pheromone gland. As the male larvae become adults, however, they retain little of the compounds. They may leave the compounds behind in the pupa or allow them to evaporate from their body surfaces. But the males probably imprint the odor of the compounds on their antennae and spend their adult lives searching for the same chemicals that turned them on as larvae.

The investigators then went on to see whether other kinds of insects also have pheromones that are part of the plants they eat. They found that this was also the case for apple-feeding insects and mushroom-feeding insects. So they conclude that most, if not all insects, borrow their sex attractants from plants.

If sex pheromones are indeed of plant origin, it could explain why some field tests with sex attractants work, and others do not. A pheromone that works for oak leaf roller moths reared in the lab on wheat germ, for example, would probably not work for moths raised in the wild on oak leaves.

On the other hand, if sex pheromones are of plant origin, they might be used more effectively for insect-control programs than they are now being used. For instance, a cheap chemical might be sprayed on foliage while larvae of a particular pest are feeding, insuring incorporation of the chemical into the larvae as sex attractants. Then, when the male larvae become adults, the same chemical could be used to trap them or to disrupt their communication with females.

The discovery that sex pheromones derive from plants may also alter insect classification. What were previously thought to be different species, because they were attracted to different pheromones, may turn out to be only a single species feeding on different kinds of plants. Theories of insect evolution based on the idea that insects from different species will not mate may also have to be changed.

The work also ties in with other research that suggests that mammals also borrow plant chemicals for their reproductive purposes. For instance, when beavers and deer eat certain substances, they give off certain smells that attract their mates. The human reproductive hormones, estrogen and estradiol, have been found in plants. "This could mean," Hendry speculates, "that we are getting our hormones directly from plants and are not making them in our own bodies. So this may be the beginning of a new era."

Scientists in the field of chemical ecology are generally enthusiastic about the findings of Hendry and his co-workers. "What they have done is very solid," asserts R. M. Silverstein, a chemical ecologist at Syracuse University. "I'm sure the findings will be substantiated by other scientists. It's just a question of how far you can extrapolate them to other insects, say from moths to beetles."

"This is strong suggestive evidence," Thomas Eisner, a chemical ecologist at Cornell University, concurs. It links up, he says, with work of his own that shows that insects borrow plant chemicals for defense purposes. □