Mastering Communication to Control Pests

Editor's Note: As insects have become increasingly resistant to conventional insecticides – and as the American public has became increasingly wary of the adverse effects of insecticides – farmers might not have been able to control the insects that threaten their livelihoods. Fortunately the development of benign pheromone-based alternatives for pest management has given farmers effective new options in their endless battle with the bugs.

Pheromones are chemical substances generated by insects themselves. As early as the 1870's it was suspected that insects emit chemical scents that attract the opposite sex. Given the techniques available to chemists at the end of the nineteenth century and the beginning of the twentieth, the mysterious substances remained elusive. Then, in the1930s, a German chemist at the Kaiser Wilhelm Institute for Biochemistry in Germany decided to pursue research to tackle the problem.

Adolph Butenandt aimed to discover the substance that female moths use to attract males. The task was difficult. He began by snipping off the abdominal tips of virgin female silkworms and grinding them up. Then, using analytical chemistry techniques, he separated the moth slurry into various extracts and tested each one on male silkworm moths. The domesticated silkworm moth has lost its ability to fly. But the male will flutter his wings when excited by a nearby female-and when fooled by one of Butenandt's extracts. Working over the course of nearly three decades, Butenandt ground up about half a million female silkworm moths in his quest to identify their alluring scent. At last in 1959, he announced success: The substance was a kind of alcohol that Butenandt christened bombykol, after the moth's Latin name, *Bombyx mori*. That same year German biochemist Peter Karlson and Swiss entomologist introduced the term "pheromone" (Greek for "carrier of excitement"). Soon others undertook the tedious effort required to seek out the pheromones made by other insects.

In 1961, Colin G. Butler at the Rothamsted Experimental Station, identified a pheromone produced by the queen honey bee that would not only suppress the rearing of queens, but also halt the development of the worker bees' ovaries.

Scientists quickly turned their attention from studying beneficial insects, such as the silk moth and the honey bee, to investigating pestiferous insects. Using behavioral assays, researchers identified the pheromones used as attractants by several moths and beetles. The wing-fluttering response used by Butenandt, remained key to identification of pheromones throughout the 1960s.

Throughout the 1960s and 1970s technical improvements dramatically quickened the pace and productivity of pheromone research. Among the improvements was the use of three techniques known as gas chromatography, mass spectrometry, and nuclear magnetic resonance. These techniques were used in combination with the electroantennogram (EAG) where an electrical charge is sent through insect antenna resulting in a peak of electrical activity in the antenna corresponding to exposure to a pheromone extract. Gas chromatography is a technique for separating components in a vapor based on how quickly they travel through a column containing an absorbent material. Mass and nuclear magnetic resonance spectrometers are used to identify chemical compositions.

Despite these successes, pheromone research still proved frustrating for many. Extracts that were highly attractive to male insects when left in their crude form mysteriously lost their allure when purified into their various components. And in many cases, synthetic compounds that passed the pheromone test in the lab failed abysmally to attract male moths in the field. It was soon discovered that single components alone often did not produce the expected results.

Although the notion of testing every fraction of a mixture in combination with every other fraction made pheromone research more complex, it also helped to explain many failures of the past. During the 1970s, several scientists reanalyzed the pheromones that had fared well in the laboratory yet failed in the field. Often they discovered that the addition of one or two more components to these single compounds improved field test results tremendously. Researchers also discovered that for many insects, if the pheromone components are not combined in the proper proportions, the mixture loses its attractiveness-or attracts a different species.

The exquisite specificity of insects' chemical language is not surprising, considering that it is often the only means insects have for finding each other. Researchers have now broken the code for the pheromone communication of more than 1,600 insects. In so doing they have found that pheromones serve many more purposes than simply attracting mates. For example, queen bees emit a pheromone that affects the development of worker bees, and ants use pheromones to recruit nest mates to a food source (which explains trails of ants at a picnic or in a kitchen). When laying their eggs, some flies, moths, and beetles use certain pheromones to repel insects of the same and competing species, thereby protecting their progeny from competition for resources. Others insects, such as aphids, give off alarm pheromones that urge neighboring aphids to flee from nearby predators. Honey bees use alarm pheromones to recruit nest mates to sting and pursue intruders. Some male moths use aphrodisiac pheromones to entice females to mate with them.

Pheromones can be highly effective at low doses and great distances. Detection of just 30 pheromone molecules can prompt a response in cockroaches. In less than five days a single caged female pine sawfly attracted more than 11,000 males from the field. From a pest management standpoint, pheromones are a critical key to manipulating insect behaviors.