PHEROMONES

—EXPLOITING AN INSECT'S SENSE OF "SMELL"

By Douglas C. Allen

For the past twenty-five years or so, entomologists and organic chemists have combined talents in an effort to understand better the manner in which insect behavior is influenced by chemical odors. This work evolved into the science of chemical ecology, which has provided much insight about the behavior of insects and other animals.

Once the chemical ecology of a pest is understood, we may be able to take advantage of this knowledge and devise control tactics that are environmentally friendly, develop species specific survey methods and enhance the effectiveness of natural enemies. This is an exciting aspect of modern day pest management that will play a significant role in our quest for sustainable forestry practices.

The Tool

Diverse odors permeate an insect's world; some of the more important chemical signals are produced by one or both sexes of a species, others emanate from the host plant. This complex of volatile (chemicals that change readily to a vapor) and nonvolatile (chemicals that do not vaporize easily and must be touched to illicit a response) compounds are used for several purposes by plant feeding insects and their associated parasites and predators. For example, they aid in locating food plants, natural enemies use them to find an appropriate insect host (host finding), certain forest pests employ chemical messages to attract relatives to a specific location (aggregating compounds), to ward off natural enemies (defensive compounds), or to enhance the mating process (sex attractants).

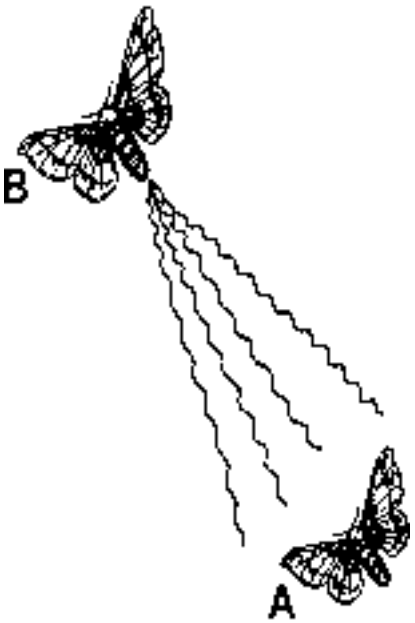

Fig. 1. Diagrammatic representation of a male moth (A) responding to a female's (B) odor plume.

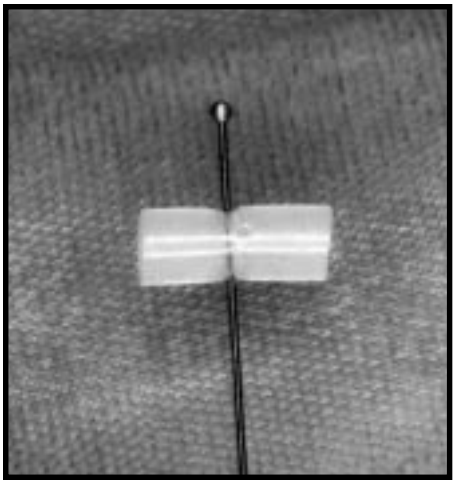

Fig. 2. This cylindrical plastic lure (3/8" long) is pinned inside a bucket or sticky trap.

Materials that comprise the latter belong to a class of behavior modifying chemicals called pheromones (ferro-moans). These substances have been exploited extensively in an attempt to manage forest pests more effectively . By definition, a pheromone is "a chemical secreted by an animal that influences the behavior of other animals of the same species". It is because of this specificity, combined with the insect's incredible ability to detect minute quantities of the pheromone, that these substances offer so much potential as a management tool. Once the structure of the behavioral chemical is determined it can be produced synthetically. After this is accomplished and efficient systems are devised to deploy the sexual attractant, it can be utilized for a range of management purposes.

How It Works

For the sake of illustration, I will use the gypsy moth, a forest and urban pest familiar to most forest owners in New York. Though winged, female gypsy moths are unable to fly and rely on a pheromone to draw males to them. This material is produced in special glands located in the last segment of the abdomen; that is, the posterior of the insect. Males, on the other hand, are very strong fliers. When ready to mate they fly more or less randomly through the forest until they get a "whiff" of the attractant. The male moth possesses very sophisticated olfactory organs embedded within its' antennae. The antennae and their associated sensory structures can detect very low concentrations of the pheromone. The pheromone level is high in the immediate vicinity of the source (i.e., the female) and dissipates as the odor plume moves down wind *(Fig. 1)*. This concentration gradient is a necessary part of the attraction process. Once the male encounters the odor plume it moves "up stream" (i.e., from an area of low to an area of relatively high pheromone concentration) until it makes visual contact with the female.

Application

Survey and detection - For biomonitoring purposes, known quantities of the synthetic attractant are impregnated in a lure of some kind, usually made of rub-

(Cont'd)

Fig. 3. Typical "bucket" type pheromone trap (8"x5").

Fig. 4. Sticky trap (8"x10"). Bottom is coated with a non-drying adhesive.

ber or plastic *(Fig. 2)*. Lures emit the attractant at a predetermined level and rate for a specified period. A lure is placed in each trap and traps are deployed in a specified manner and location, depending on the habits of the insect. Bucket-type models *(Fig. 3)* contain an agent that kills moths shortly after they enter the trap. Sticky traps *(Fig. 4)* are lined with an adhesive which retains moths on contact. Selection of a trap model is determined by a specific insect's behavior, size, population level, and the user's biomonitoring objectives.

These trapping systems provide an inexpensive, efficient and sensitive method to determine the presence or absence of a pest, to estimate differences in pest density from one location to another or to predict changes in relative abundance from one year to the next.

Surveys that utilize pheromone-baited traps are very effective at host densities so sparse it would be prohibitively expensive to sample populations in any other way.

Mating disruption - the purpose of this application is to permeate the insects's environment with enough synthetic pheromone to disrupt the mating process. Disruption results when the male is unable to orient to the female because the odor gradient is eliminated when the insect's environment is saturated with attractant. Also, under these conditions males may become habituated to the odor; that is, they do not "recognize" it as something unique and fail to respond to the stimulus. This use is most applicable at very low pest densities where the distance between individuals is great, relative to high populations, and effective chemical communication is critical to assure a meeting of the sexes.

Mass trapping - for this use, the synthetic pheromone is placed in some type of trap for the purpose of capturing a large enough segment of the pest population to lower damage levels. The approach is most applicable in situations where the pest population is confined to a small area.

Antiaggregation - many important bark beetle pests use pheromones to "inform" relatives when population numbers are likely to exceed the food supply. By regulating the density of individuals attacking a tree or log, the negative effects of competition for food are minimized. When we send a "false" message by saturating a forest stand or plantation with this type of pheromone, insects are discouraged from searching for hosts in this particular area. In other words, they get a "message" that the resident population is too dense relative to available food.

The three forest pests for which pheromone trapping is used most extensively in the northeastern United States to detect changes in population trend are gypsy moth, spruce budworm and forest tent caterpillar. Because this monitoring tool is so effective at low pest densities, it provides a sensitive early warning system which identifies threatening situations before significant damage occurs. ▲

This is the 33rd in the series of articles contributed by Dr. Allen, Professor of Entomology at SUNY-ESF.
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