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Insect Attractants and Traps [1]

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Many chemical and visual lures attract insects and can be used to monitor or directly reduce insect populations. Because these attractants are used in ways that do not injure other animals or humans or result in residues on foods or feeds, they can be used in an environmentally sound manner in pest management programs.

The effective use of attractants and traps requires knowledge of basic biological principles and the pest- or crop-specific details involved in individual applications. This publication presents background information and specific guidance on the use of attractants and traps for monitoring and directly controlling insect pests. Its purpose is to aid farmers, homeowners, and others in understanding and making appropriate use of available technology. It covers chemical attractants, visual lures (such as light), and attractant-baited and unbaited traps.

Chemical Attractants

Insects use many different **semiochemicals**, chemicals that convey messages between organisms. (The Greek word "semeio" means sign.) Although semiochemicals may seem analogous to tastes or smells perceived by humans, the use of such compounds by insects is characterized by a high degree of sensitivity and specificity. Receptor systems that ignore or screen out countless irrelevant chemical messages are nonetheless able to detect messenger compounds at extremely low concentrations. Detection of a chemical message triggers very specific unlearned behaviors or developmental processes.

Chemicals that act as attractants or carry other messages across distances are volatile (quick to evaporate) compounds. When released into the air, they can be detected by certain insects (those receptive to a specific compound) a few inches to hundreds of yards away. Chemicals that carry messages over considerable distances are most often used in pest management.

Although this publication does not rely on special terminology, a few terms provide useful background. First, semiochemicals may carry messages either within or between species. **Pheromones** are semiochemicals that are produced and received by members of the same species. A range of behaviors and biological processes are influenced by pheromones, but pest management programs most

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often use compounds that attract a mate (sex pheromones) or call others to a suitable food or nesting site (aggregation pheromones). Other pheromones regulate caste or reproductive development in social insects (honey bees and termites for example), signal alarm (in honey bees, ants, and aphids), mark trails (ants), and serve other functions.

Allelochemicals are semiochemicals that affect one or more species other than the producer. Of known allelochemicals, volatile compounds similar to those given off by food sources (plants or animals) are important in pest managements. Feeding attractants are examples of **kairomones**, allelochemicals produced by one species but used to advantage by another species. For example, carbon dioxide given off by humans and other animals is used as a kairomone by female mosquitoes seeking a blood meal. In contrast, **allomones** are allelochemicals that favor the producer. For example, secretions that deter predators are allomones.

Although terms such as pheromone or kairomone help describe the functions of message-carrying chemicals, these words often oversimplify the complexity of chemical communication. A single chemical signal may act as both a pheromone and a kairomone; for example, the compounds emitted by a bark beetle colonizing a host tree attract other bark beetles (functioning as an aggregation pheromone), but the same compounds also attract certain predators and parasites that attack these bark beetles (functioning as a feeding attractant or kairomone).

Practical use of pheromones or feeding attractants for pest management usually requires that specific active chemicals be isolated, identified, and produced synthetically. The synthetic attractants--usually copies of sex or aggregation pheromones or feeding attractants--are used in one of four ways: (1) as a lure in traps used to monitor pest populations; (2) as a lure in traps designed to "trap out" a pest population; (3) as a broadcast signal intended to disrupt insect mating; or (4) as an attractant in a bait containing an insecticide.

Using Attractant-Baited Traps to Monitor Pest Populations

The most common use of chemical attractants is in traps to monitor insect populations. Although not all of the compounds used in this manner are pheromones, many publications refer to all attractant-baited traps as pheromone traps. For use in monitoring, chemical attractants usually are impregnated or encased in a rubber or plastic lure (Figure 1) that slowly releases the active component(s) over a period of several days or weeks. Traps containing these lures are constructed of paper, plastic, or other materials (Figure 2). Most traps use an adhesive-coated surface or a funnel-shaped entrance to capture the target insect. Traps for some pests (such as the apple maggot) are coated with an adhesive that also contains the chemical attractant.

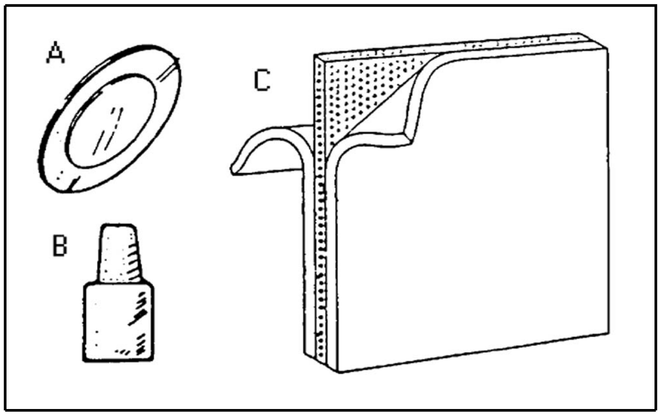

Figure 1. Insect attractants are often impregnated or encased in lures such as (A) Biolure's membrane-covered disk; (B) Trece's rubber septum; and (C) Hercon's plastic laminate lure.

Attractant-baited traps are used instead of (or in addition to) other sampling methods for two major reasons. First, these traps are very sensitive and may capture pest insects that are present at densities too low to detect with a reasonable amount of effort using other inspection methods. This attribute can be extremely important when the goal of a sampling program is to detect foreign or "exotic" pests as soon as they enter an area so that control measures can be initiated immediately. Second, traps baited with chemical attractants capture only one species or a narrow range of species. This specificity simplifies the identification and counting of target pests. Sensitivity and specificity make attractant-baited traps efficient, labor-saving tools.

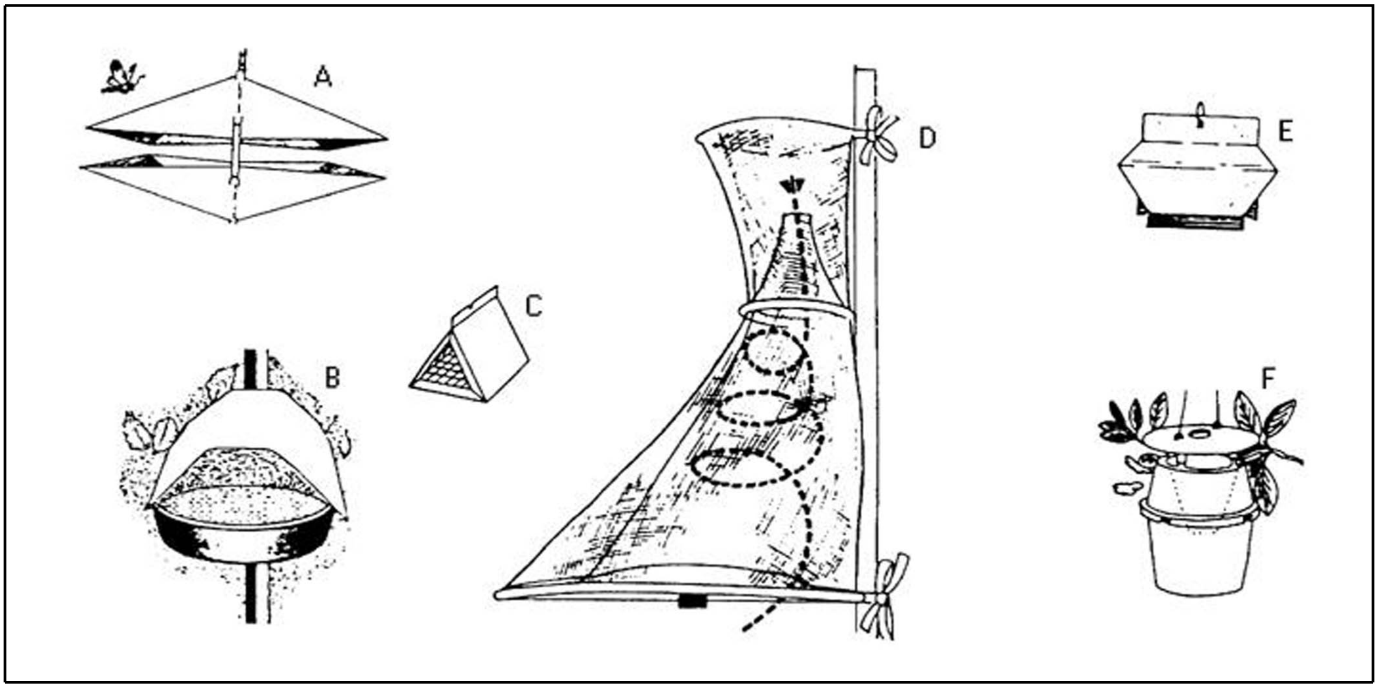

Figure 2. Commercially available traps used for monitoring insect populations include (A) the "wing" trap; (B) the water pan trap; (C) the Delta trap; (D) the Heliothis trap; (E) the PHerocon II trap; and (F) the funnel trap. Several other trap designs are also available.

Attractant-baited traps are used in monitoring programs for at least three purposes: (1) to detect the presence of an exotic pest (an immigrant pest not previously known to inhabit a state or region); (2) to estimate the relative density of a pest population at a given site; and (3) to indicate the first emergence or peak flight activity of a pest species in a given area, often to time an insecticide application or to signal the need for additional scouting. The use of traps to detect exotic pests has been demonstrated in widely publicized efforts to detect and eradicate pests such as the gypsy moth and the Mediterranean fruit fly whenever infestations are detected in new areas.

Although attractant-baited traps give an indication of pest density, several factors make the interpretation of density estimates complex and difficult. First, environmental factors affect trap catches. Temperature, rainfall, and wind speed and direction influence attractant release (from lures) and insect flight. Many insects fly and respond to semiochemicals only at certain time (dawn, midday, dusk, night, etc.), and then only if temperatures at that time exceed a minimum level (often 50 to 60° F). Wind speed and direction determine the extent of insect movement from surrounding areas to traps within a field or orchard.

Further complication can result from the fact that almost all attractant-baited traps are used to capture adult insects. Damage to crops, however, is caused not by the adult male moths attracted to the traps but by the subsequent generation of caterpillars that female moths produce. Because variable environmental conditions and variable densities of natural enemies greatly influence pest survival between the time trapping data are collected and the time pest damage occurs, establishing a precise economic threshold (the pest population level that warrants control) based on trap counts is difficult. Where counts from traps are used to estimate pest density and determine control needs, guidelines are usually conservative or somewhat vague.

Attractant-baited traps can be used to signal the need for additional sampling efforts or to time insecticide applications and eliminate unnecessary spraying. One example of the use of pheromone traps to trigger further sampling involves the black cutworm, a common but sporadic pest of seedling corn in the Midwest. Pheromone traps baited with a specific sex attractant are used in a statewide sampling program to monitor the annual spring migration of black cutworm moths from southern states into Illinois. In area where counts of male moths in traps indicate the potential for damaging infestations of cutworm larvae, producers are urged to check for cutworm density and crop damage in fields of seedling corn. For pests that cause unacceptable levels of damage even at low population densities, such as the codling moth or apple maggot in commercial apple orchards, traps can be used as the only sampling method for determining the dates to begin and end insecticide application programs.

For all programs that use traps of any type, trap design and trap placement are important factors. For example, common paper sticky traps are ineffective for monitoring corn earworm moths. Male corn earworm moths that are attracted to a chemical lure seldom enter these box- or tentlike traps. Instead, a much larger, cone-shaped trap must be used to capture this insect (Figure 2). Similarly, placing traps at the correct height and in the correct portion of a field (edge or center) or building is sometimes the key to detection or interpretation.

Using Attractant-Baited Traps to "Trap Out" Pest Populations

Because pheromone traps are so effective for catching certain insects, numerous traps placed throughout a pest's environment can sometimes remove enough insects to substantially reduce the local population and limit the damage it causes. Efforts to "trap out" insect pests (a process also termed removal trapping or mass trapping) have utilized species-specific aggregation pheromones that attract both male and female beetles or species-specific sex pheromones that attract male moths. When aggregation pheromones are used to attract adult beetles of both sexes, traps may reduce the feeding damage caused by the adult insects and reduce reproduction by capturing adults before they lay eggs. When sex pheromones are used to capture moths, success depends upon capturing males before mating occurs.

Although mass trapping programs using chemical attractants have targeted such important pests as bark beetles, codling moth, apple maggot, Japanese beetle, and Indianmeal moth, field-scale successes have been limited. For mass trapping to adequately reduce pest populations, a large number of very efficient traps are usually needed. Efficient traps capture a high percentage (and often a very large volume) of the target insects that are drawn to the area by the attractant. For many insects, the efficiency of commonly used traps is not known; however, low efficiency seems to be a limiting problem in some instances. Removal trapping is also most likely to succeed when the density of the target pest is low and immigration into the trapped area is minimal.

The following examples illustrate conditions that favor or limit the potential use of mass trapping.

Codling Moth

Larvae of the codling moth tunnel into apples and pears, leaving the fruit scarred, contaminated, and unsuitable for most commercial markets. Although pheromone traps are used to monitor the seasonal timing and sometimes the density of codling moth populations in commercial orchards, mass trapping has not been widely adopted. In experimental programs, high numbers of pheromone traps (14 and 72 traps per acre) in some trials provided less control of subsequent larval damage than did fewer traps (4 per acre) in other trials. These seemingly contradictory results appear to have resulted from different conditions in and surrounding the test orchards. Available data indicate that mass trapping for codling moth control is likely to be successful only in reasonably isolated orchards (at least 100 yards and preferably further from the nearest source of moths) where codling moth populations are already low. Where nearby fruit trees harbor codling moth infestations, mated female moths can disperse into the trapped orchard and lay eggs even if the local males have been trapped. (Immigration also prevents the successful use of mass trapping to protect fruit on one or two backyard trees in most urban situations.) Where initial moth populations are high, some males will locate and mate with a nearby female even if a great number of traps have been used; in these orchards the mated females produce enough fertile eggs to damage a measurable portion of the fruit. Despite these limitations, mass trapping can reduce codling moth damage in some orchards. Although damage may not be limited to the extremely low levels required by most commercial markets, producers who sell to "organic" markets might use mass trapping along with other steps (such as removal of dropped fruit and banding of trunks) to substantially limit codling moth damage. Because the number of traps needed for mass trapping of codling moths has not been determined, the economic feasibility of mass trapping is unclear. However, Trece, Incorporated manufactures a pheromone TRAP-Pherocon® ICP TRAP that can be used to monitor the insect population during control measures.

Japanese Beetle

Adult Japanese beetles eat the leaves of many different ornamental plants (both trees and shrubs), and the larvae (grubs) or this species feed on the roots of grasses. Can- or baglike traps for Japanese beetles contain a feeding attractant alone or in combination with a sex attractant. These traps are sold under claims that they will reduce beetle numbers and protect nearby plants from feeding damage. Although their lures are indeed very attractive to adult Japanese beetles, the use of these traps in areas where the Japanese beetle is prevalent has been shown to increase beetle numbers and damage to host plants in the area around the trap. This outcome apparently results from the fact that many beetles are attracted by the lure but not captured by the trap. In areas where the Japanese beetle is a serious pest, only very widespread use of many traps (several traps per homeowner by a majority of homeowners in an area) is likely to reduce damage to plant foliage. In contrast, in areas where Japanese beetle densities are low, traps placed several yards away from valuable plants can reduce the damage caused by adult beetle feeding on foliage or flowers. Additionally, these traps have been used at densities of one or two per acre to remove adult beetles from golf courses and to reduce turf damage caused by the subsequent generation of grubs. To monitor populations place lures at the perimenter of property. Trece, Incorporated manufactures a product called Japanese Beetle-3-way Lure. It containes a chemical (Eugen) that is highly attractive to adult Japanese beetles.

Using Attractants to Disrupt Insect Mating

To disrupt insect mating, a species-specific sex attractant is broadcast throughout an area. In an environment permeated with artificially applied sex pheromone molecules, male insects that rely on pheromones to locate females are unable to do so. They either follow an artificial signal to a frustrating destination or their sensory receptors become overloaded by constant exposure to pheromone molecules, leaving the insect temporarily unable to detect additional pheromone messages. The way in which artificial attractants might "out-compete" female moths and prevent their success in attracting a mate is illustrated in Figure 3.

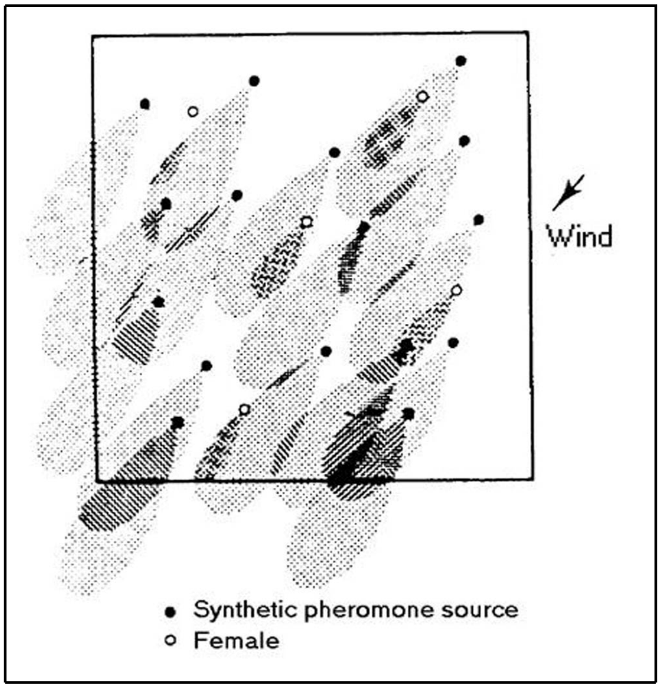

Figure 3. Synthetic attractants used in mating disruption programs produce "odor" plumes that obscure the locations of females. Males attempting to follow a plume upwind and locate a female will most often reach a synthetic lure, and many females will fail to attract a mate. (Illustration from Birch and Haynes, 1982).

In field applications of mating disruption techniques attractants have been applied to fields or forests in hollow plastic fibers, capsule like pellets, and attractant-impregnated plastic strings or ties. Although mating disruption programs are not widely used, trials have been successful against the oriental fruit moth, pink bollworm in cotton, grape berry worm, tomato pinworm, and several pests of forest conifers. The trial use of pheromones to disrupt mating for codling moth control in apples has produced mixed results. Mating disruption programs are most successful where large areas are treated, where the treated area is isolated from sources of pests that might immigrate, and where the pest population is low. When pest densities are low, artificial attractants are more likely to out compete a high percentage of female insects in attracting males. For insect attractants to be broadcast into the environment for direct control, the attractants (regulated as pesticides) must be evaluated and approved by the US Environmental Protection Agency. The sex attractant of the oriental fruit moth has been approved for such use in plastic "ropes" to be tied onto the limbs of fruit trees.

Using Attractants in Poison Baits

Combining insect attractants with poisons (insecticides) is a practice that has been used in pest management for many years. In the early 1900s, for example, poisoned bran baits were used for grasshopper control; hoppers that were attracted to the treated bran and fed on it were killed by an insecticide that could not be applied safely, economically, or effectively in any other manner.

Because pests are lured to toxic compounds that are combined with attractants, poisoned baits can sometimes be used effectively at low rates and often in a manner that does not leave residues on plants or animals. Insecticidal baits are used currently in the control of several pests including the house fly, slugs, certain ants, cockroaches, and yellow jackets. Research in progress is investigating the use of feeding attractants and feeding arrestants (cucurbitacins) derived from wild squash in combination with an insecticide to control adult corn rootworm beetles.

Visual Lures

That light attracts many insects is common knowledge, but making use of light and its component colors in visual lures requires considerably more detailed understanding. Visual lures used in insect management fall into three general categories: (1) lights (incandescent, fluorescent, and ultraviolet) that attract insects from dark or dimly lit surroundings; (2) colored objects that are attractive because of their specific reflectance; and shapes or silhouettes that stand out against a contrasting background.

Using Lights to Attract Insects

A great number of insect species are attracted to light of various wavelength. Although different species respond uniquely to specific portions of the visible and nonvisible spectrum (as perceived by humans), most traps or other devices that rely on light to attract insects use fluorescent bulbs or bulbs that emit ultraviolet wavelengths (black lights). Hundreds of species of moths, beetles, flies, and other insects, most of which are not pests, are attracted to artificial light. They may fly to lights throughout the night or only during certain hours. Key pests that are attracted to light include the European corn borer, codling moth, cabbage looper, many cutworms and armyworms, diamondback moth, sod webworm moths, peach twig borer, several leaf roller moths, potato leafhopper, bark beetles, carpet beetles, adults of annual which grubs (*Cyclocephala*), house fly, stable fly, and several mosquitos.) The mosquitoes *Ochlerotatus* (formerly *Aedes*) *triseriatus*, *Ochlerotatu* (also formerly *Aedes*) *hendersoni*, and *Aedes albopictus* are not attracted to light, however.) Lights and light traps are used with varying degrees of success in monitoring populations and in mass trapping.

Light traps similar to the one pictured in Figure 4 have been used for several decades to monitor the presence of insects and to determine seasonal patterns of pest density. But because pheromone traps are much more specific (they catch only one or a few pest species instead of many) and more convenient, light traps are no longer as widely used. Nonetheless, light traps provide useful information about the timing, relative abundance, or species composition of flights of European corn borer, white grubs, sod webworms, and a few other pests.

Although numerous companies market devices that use light as a lure for mass trapping or removal trapping, using light to trap out insect infestations is effective in only a few specific situations. One widely used but very ineffective application of light for insect control is the placement of electrocutors or "bug zappers" on lawns or patios. Such uses are ineffective for at least two reasons. First, many insects that are attracted to the area around the light traps (sometimes from considerable distances) do not

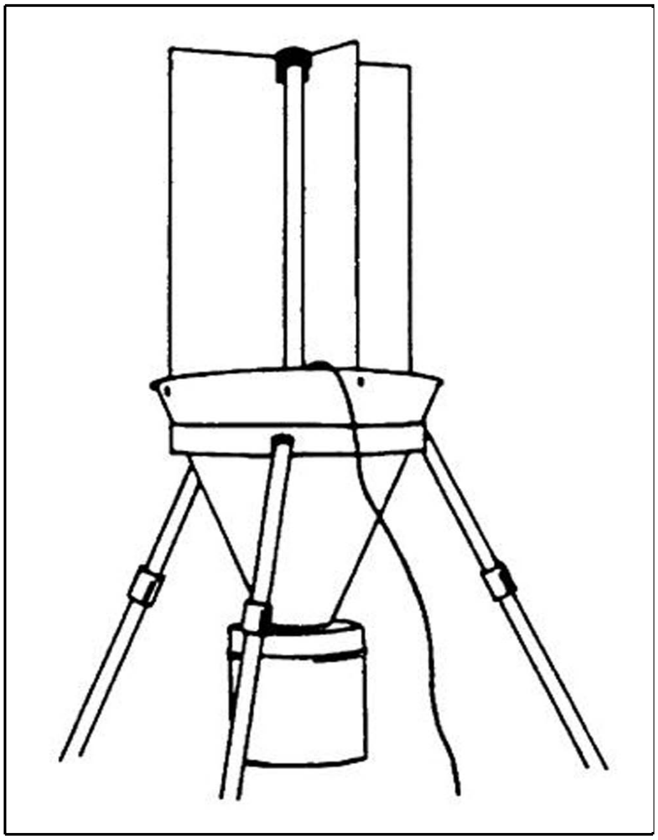

Figure 4. A light trap used to survey nught-flying insects. Most light traps use ultraviolet lamps and capture a wide range of moths, beetles, and other insects.

actually fly into the trap. Instead, they remain nearby, actually increasing the total number of insects in the immediate area. Second, these lighted electrocutors attract and kill a wide variety of insects, the overwhelming majority of which are not pests. The nonpest species killed by such devices include such beneficial insects as the green lacewing, a predator that attacks a variety of plant pests.

Insect electrocutors can be effective in certain indoor situations, especially in food warehouses, processing plants, and restaurants. In these facilities, electrocutors are placed in otherwise dimly lit areas where their light is not visible from outdoors. In such locations the trap does not lure insects into the building, yet it does attract and kill certain flies, moths, and beetles that are pests of stored products or nuisances in food production areas (see Gilbert, 1984). These traps can also be used somewhat effectively in barns and stables to reduce some fly and mosquito infestations. The efficiency of electrocutors in such situations appears to be low, however, and they must be positioned so that they do not attract insects into a building from outdoors.

Although using electrocutor-light traps outdoors is not efficient, the placement of outdoor lights can be important. Positioning outdoor lights away from entrances, windows, or other openings reduces problems associated with insect activity around the lights. Flood lights directed at loading docks, for instance, do not lure insects into food warehouses as so overhead lights mounted just inside the loading dock door. Placing outdoor lights several feet away from doors of homes and apartments also concentrates insect activity away from the sites where they cause the most annoyance. In addition, yellow light bulbs attract fewer insects that white incandescent lights or fluorescent bulbs.

Using Colored Objects to Attract Insects

Specific colors are attractive to some day-flying insects. For example, yellow objects attract many insects and are often used in traps designed to capture winged aphids and adult whiteflies. Red spheres and yellow cards attract apple maggot flies. Like other attractants, colored objects can be used in traps for monitoring or mass trapping. Yellow plastic tubs filled with water, for example, are used to monitor the flights of aphids in crops where these insects are important vectors of plant viruses. Aphids attracted to the yellow tub land on the water and are unable to escape. Yellow, sticky-coated cards or plastic cups are widely used in mass trapping programs to help control whiteflies in greenhouses. Although recommended trap densities in greenhouses are based on studies involving only a few crops, recommendations of 1 trap per 5 square yards or 1 trap every 3 to 4 feet along benches are common. Yellow sticky traps capture adult whiteflies, not wingless nymphs.

Both yellow cards and red spheres (and red hemispheres attached to yellow cards) coated with adhesives are used to attract and capture apple maggot flies in orchards. A chemical attractant is incorporated in the adhesive applied to commercially available yellow cards. Apple maggot traps are most often used to detect the movement of adult flies into orchards from nearby overwintering sites. To do so, traps should be placed in trees along the perimeter of the orchard, with no more than 150 feet between traps. The timing of insecticide applications can be based on the results of such a trapping program.

Research indicates that red sphere traps and chemical attractants can be used to "trap out" apple maggot flies and limit damage to fruit. For mass trapping programs to work, traps must be in place before flies begin to move into orchards (in early June), and a great number of traps must be used (one every 15 feet in the trees at the perimeter of the orchard). Mass trapping for apple maggot control is still an experimental approach, and commercial producers should not adopt a mass trapping program if complete control of apple maggot damage is necessary.

Traps used to capture stable flies around livestock and outdoor recreation facilities are constructed of alsynite, a translucent building material similar to fiberglass. It is attractive to stable flies apparently because of its specific reflectance. Alsynite panels coated with adhesive are used to determine stable fly abundance, and their effectiveness in mass trapping is under investigation. Although these traps can provide some control of stable flies in isolated sites, their value in feedlot and dairy situations has not been established. If alsynite traps are to be effective in these settings, producers will need to use many traps (an adequate number has not been determined).

Other Traps

Several unique types of traps are used for the control of various species of flies. House fly traps containing foods or chemical attractants lure house flies to a reservoir from which they cannot escape. These traps capture thousands of house flies around livestock facilities, but the overall population in such areas is usually not reduced by a meaningful level unless a great number of traps are used. The effectiveness of such traps must be judged not by the number of flies in the traps by the number of flies still present in the area. (These traps do not capture stable flies, the biting flies that are most annoying to livestock.)

Because house flies commonly land and rest on narrow, vertical objects, hanging sticky "fly strips" is somewhat effective in small, closed areas where fly populations are low. Although these strips quickly become coated with flies where flies are numerous, they can be useful on a closed porch or similar indoor area. Because flies often land near other flies, strips that have captured a few flies and strips that bear pictures of flies may be more effective than clean strips. (Strips should be hung so that people do not inadvertently contact them; the adhesive combined with dead flies is an unpleasant addition to hair or clothing.)

Other traps designed to control certain pasture flies can be constructed from commonly available materials. Walk-through traps for horn fly control can reduce horn fly infestations on cattle by 50 to 70 percent. Box or canopy-type traps rely on the horse fly's attraction to dark silhouettes. Although horse fly traps are impractical where horses or cattle graze in large pastures or extensive rangelands, they can reduce horse fly numbers in small pastures.

One other type of trap useful to gardeners and farmers is the pitfall trap (Figure 5). Perhaps its best known use is in slug control. Bowl, cups, or other containers are set into the soil surface. Beer or a fermented mixture of flour, sugar, yeast, and water is added to the container to attract slugs; slugs that enter the container are unable to escape and "drown" in the liquid. Similar pitfall traps containing a preservative (not an attractant) are sometimes used to sample populations of insects active at the soil surface. Relatively new pitfall traps are now available for detecting beetle infestations in stored grains. These traps can be used with or without an attractant to provide a very sensitive measure of insect presence in warm grain.

Summary

Insect attractants and traps are useful tools for monitoring insect populations to determine the need for control or the timing of control practices. In some instances, attractants and traps also can be used to control insect populaions directly by mass trapping or mating disruption. Using attractants and traps to monitor and control insect populations can improve the effectiveness of insecticide applications and sometimes reduce the use of broad-spectrum, more toxic compounds.

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