Insect Attractants and Traps

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 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 management. 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).

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Practical utilization 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.

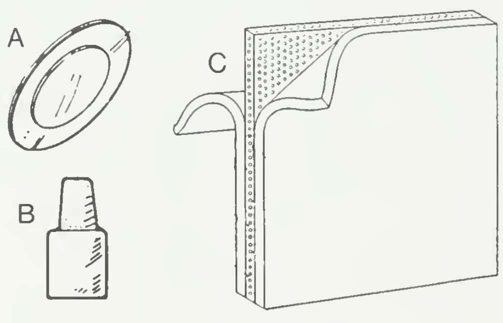

Figure 1. Insect attractants are often impregnated or encased in lures such as (A) Biolure's membrane-covered disk; (B) Trece's rubber septum; and (C) Hercon's plastic laminate lure.

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.

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 times (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

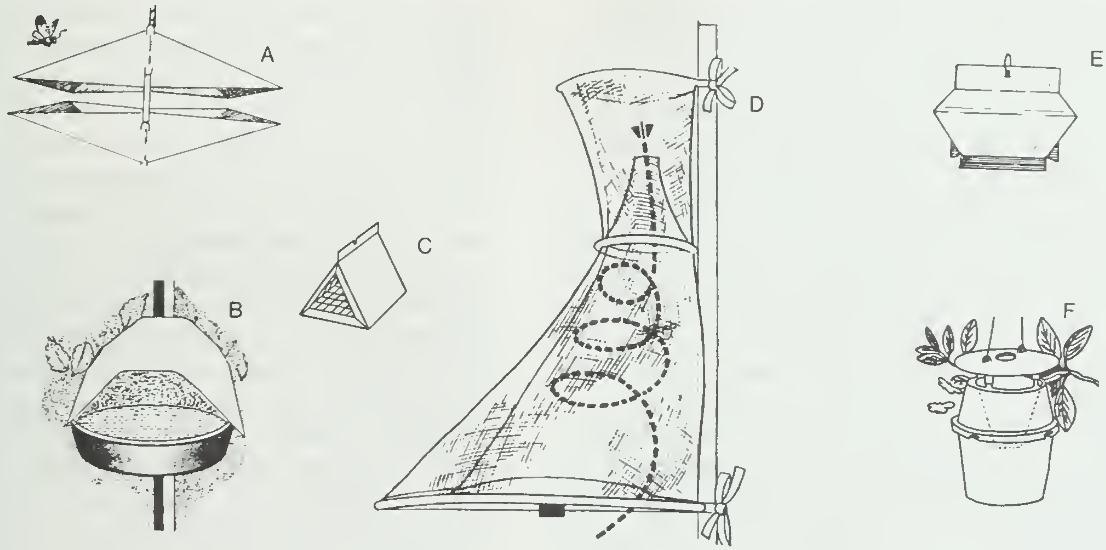

Figure 2. Commercially available traps used for monitoring insect populations include (A) the "wing" trap; (B) the water pan trap; (C) the Delta trap; (D) the Heliothis *trap; (E) the Pherocon II trap; and (F) the funnel trap. Several other trap designs also are available.*

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 areas 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 (see Table 1). 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. Recommendations on trap selection and trap placement for specific insects are included in Table 1.

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 recommendations presented in Table 1 include information on mass trapping for pests that might be managed by such an approach. In addition, 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.

Japanese Beetle. Adult Japanese beetles eat the leaves of many different ornamental plants (both trees and shrubs), and the larvae (grubs) of 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 beetles 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.

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.

In field applications of mating disruption techniques, attractants have been applied to fields or forests in hollow plastic fibers, capsulelike 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.

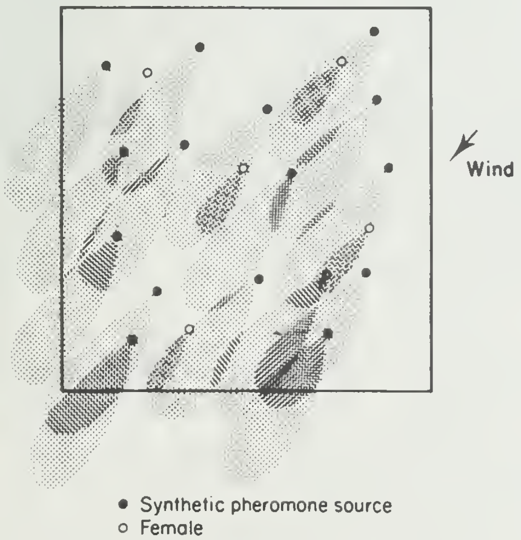

*Figure 3. Synthetic attractants used in mating disruption programs produce "odor" plumes that obscure the locations of females. Males attempting to follow a plume upwind and locate a female will most often reach a synthetic lure, and many females will fail to attract a mate. **(Illustration from Birch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

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 yellowjackets. 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. Table 1 lists baits that allow unique, low-rate applications of insecticides.

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 (3) 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 wavelengths. 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 white grubs

(Cyclocephala), house fly, stable fly, and several mosquitoes. (The mosquitoes *Aedes triseriatus*, *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 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.

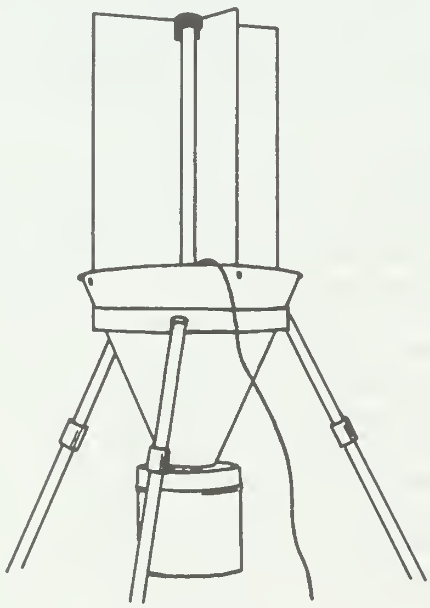

Figure 4. A light trap used to survey night-flying insects. Most light traps use ultraviolet lamps and capture a wide range of moths, beetles, and other insects.

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 do 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 than 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. See Table 1 for further details on using traps for apple maggot.

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 but 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. See Table 1 for additional information on traps designed for fly control.

One other type of trap useful to gardeners and farmers is the pitfall trap. Perhaps its best known use is in slug control. Bowls, cups, or other containers are set into the soil so that the lip is level with 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 (Figure 5). These traps can be used with or without an attractant to provide a very sensitive measure of insect presence in warm grain. Table 1 contains additional information on traps for stored-grain insects.

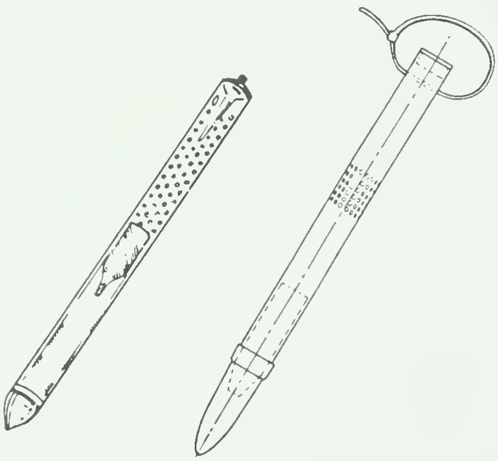

Figure 5. Perforated pitfall traps are used to detect or monitor populations of insects in stored grains. Such traps are sold under the names Storgard Grain Probe, Grain Guard, and Storgard WB Probe II.

Tables 1 and 2 provide specific details about the purchase and use of attractants and traps: Table 1 lists recommendations for specific pests; Table 2 lists several manufacturers and distributors of attractants and trap supplies.

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 populations 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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RELATED EXTENSION PUBLICATIONS*

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C1298 Alternatives in Insect Management: Beneficial Insects and Mites

**Titles available as of February 1990.*

Table 1. Guidelines for Specific Uses of Attractants and Traps

PEST	TRAPPING PERIOD	INSTRUCTIONS, INTERPRETATION, COMMENTS
Field Crop Pests		
Black cutworm, *Agrotis ipsilon*	March - May	Use wing traps baited with specific sex attractant; place 3 to 4 feet high on stakes in fields or along field edges. Check daily. Results do not predict field-specific risks at the trap site. A statewide trapping program operated by the Coop. Extension Serv. determines timing and intensity of spring moth flight. Further sampling is especially important in regions where moth captures exceed 9 per trap per night (= "intense" flight). Begin sampling for larvae and damage 300 degree days after intense flight. Control decisions are based on larval density, plant damage, and growth stage of cutworms and plants. See Curran et al. (1989).
European corn borer, *Ostrinia nubilalis*	June 1 - Aug 20	Use water pan traps with specific sex attractant; place traps 4 to 5 ft. high on stakes in grassy areas near field edges. Counts indicate peak flight periods and timing for further sampling; they do not allow prediction of damage or control needs for individual fields. See Showers et al. (1989) for further details on decision-making for corn borer control. Light traps are also effective for determining the flight period of European corn borer.
Northern & western corn rootworms, *Diabrotica* spp.	Aug 10 - 30 (See comments)	Dates for monitoring vary according to weather and planting date; begin trapping when corn is silking. Use unbaited yellow sticky traps such as the Pherocon AM (Trece, Inc.). Use 8 to 12 traps evenly spaced throughout each field, positioned near corn ears. Check twice weekly. Maintain for at least 7 days. Captures of more than 6 beetles per trap per day indicate potentially damaging populations (populations that will produce enough eggs/larvae to result in economic damage to the roots of corn planted in the same field the next year). Toxic baits containing attractants derived from wild squash are under investigation and preliminary results are promising.
Corn earworm, *Heliothis zea*	At early stages of silking in seed corn	Use large cone-shaped traps constructed of wire or plastic mesh ("Heliothis traps") and baited with specific sex attractant. Position on stake so that bottom of trap is 4 to 6 feet above soil. Place near fields where corn is beginning to silk. Traps indicate the presence or absence of moths during the period when seed corn is susceptible to damage. No threshold based on moth counts has been established.

PEST	TRAPPING PERIOD	INSTRUCTIONS, INTERPRETATION, COMMENTS
Armyworm, *Pseudaletia unipuncta*, and Fall armyworm, *Spodoptera frugiperda*	May 1 - autumn	Wing traps and specific attractants for armyworm and fall armyworm are available, but their use in field crops provides little benefit. Although they indicate the presence and timing of moth flights, control decisions must be made later when partially mature larvae are present.
Orchard Pests		
Codling moth, *Cydia pomonella*	Bloom through harvest	Begin trapping in April in southern Ill., May in central and northern Ill. For monitoring, use specific sex attractant in IOBC cartons or modified wing traps such as the Pherocon 1CP (from Trece, Inc.) placed 6 ft. high or 1/3 up the vertical canopy. Place in south or east quadrant of tree within 2 ft. of outer edge of canopy. Use at least 1 trap per 10 acres and a minimum of 3 traps in small orchards. Count and remove moths twice weekly. Counts indicate timing of moth flights and need for cover sprays. Threshold estimated at 5 moths/trap/week. Difficult to employ mass trapping or mating disruption because mated females enter orchards from nearby wooded areas. For information on mating disruption and mass trapping, see Reidl et al. (1986). (Wrapping trunks with burlap to capture larvae as they move down trunks to overwintering sites and then destroying the collected larvae can reduce numbers wintering in orchards; wrapping will not eliminate the next season's damage.)
Apple maggot, *Rhagoletis pomonella*	June 1 - Oct 15	Use red spheres or yellow sticky traps baited with feeding or egg-laying attractants. To monitor flights, place at 150-ft. intervals around orchard borders. Traps at borders near woods or abandoned orchards are most important. Place 6 ft. high on limb at outside edge of canopy (no foliage within 1 ft.) on south side of tree. Check twice weekly. Treat when cumulative counts reach 15/trap. Restart count at zero and retreat each time cumulative count reaches 15/trap. For mass trapping, use 1 trap every 15 ft. along orchard perimeter. Mass trapping can be effective in small orchards (perhaps 5 to 15 acres) but is less likely to work well in large orchards. Apple maggot is common in northern Illinois but rarely occurs in orchards in the southern two-thirds of the state.
Peachtree borer, *Synanthedon exitiosa*, and Lesser peachtree borer, S. *pictipes*	May - Sept	Most important monitoring period for peachtree borers corresponds with timing of local apple blossoms. Use wing traps baited with sex attractant and hang 3 ft. high on or adjacent to trunks. 1 trap per 2 1/2 acres; at least 2 traps per orchard. Check twice weekly. Time trunk sprays a few days after first captures. Pheromone products for use in mating disruption are under development.

PEST	TRAPPING PERIOD	INSTRUCTIONS, INTERPRETATION, COMMENTS
Peach twig borer, *Anarsia linetella*	May - Sept	Rarely a pest in fruit orchards. See **Pests of Woody Ornamentals and Shade Trees.**
San Jose scale, *Quadraspitiotus perniciosus*	At "pink" stage of bloom	Use tent traps (from Trece, Inc.) with sex attractant, at least 4 per orchard, or in or near infested trees (identified from previous season's fruit damage). Place 6 ft. high on limb near edge of canopy, or place in upper half of canopy to increase detection sensitivity. Check twice weekly. Traps indicate success of oil sprays applied at half-inch green and at tight cluster; crawler activity begins 2 to 4 weeks after males are captured in traps. Crawler activity also can be measured using sticky tapes (such as black electrical tape) on twigs and branches.
Spotted tentiform leafminer, *Phyllonorycter* spp.	"Delayed dormant" bud stage through end of season	Use wing trap or dark red sticky board baited with sex attractant. Use at least 2 traps per orchard; place 6 ft. high on limb near edge of canopy. Check twice weekly; heavy flights often occur where leafminers were a problem the previous year. Traps indicate timing; correlation between trap catches and larval damage is low. Follow trapping by checking foliage. Economic threshold is estimated at 1 to 3 miners per leaf.
Redbanded leafroller, *Argyrotaenia velutinana*	July 1 - harvest	Use wing traps with sex attractant. One trap per 5 acres; minimum of 2 traps per orchard. Hang 6 ft. high on limb at outer edge of canopy; check twice weekly. Redbanded leafroller is a minor pest of apples in Illinois; the third generation is most damaging and occurs near harvest. Traps indicate presence and timing of this generation.
Oriental fruit moth, *Grapholitha molesta*	Fruit-set - harvest (peaches)	To monitor, use wing traps with specific sex attractant; 1 trap per 5 acres, minimum of 2 traps per orchard. Hang 6 ft. high on limb in northeast quadrant of tree, 1 to 2 ft. from edge of canopy. Monitor twice weekly. Traps indicate presence and timing of second and third generations of moths (subsequent larvae bore into fruit). Apply cover spray at peak flight (about 2 weeks after first capture). Mating disruption can be used in orchards where first generation damage (tunneling into terminals) indicates pest presence. Use attractant-impregnated plastic ties (Isomate M from Biocontrols, Inc. or Checkmate OFM from Consep Membranes) according to manufacturer's directions.

PEST	TRAPPING PERIOD	INSTRUCTIONS, INTERPRETATION, COMMENTS
Fruittree leafroller, *Archips argyrospila*	June - July	Use wing traps with specific sex attractant. One trap per 5 acres; minimum of 2 traps per orchard. Hang 6 ft. high on limb at outer edge of canopy; check twice weekly. Trap indicates presence of moths, but eggs they deposit in June or July do not hatch until the following spring. Counts of moths in traps are not good predictors of subsequent larval density; sample for larvae and damage in foliage in spring to determine control needs.
Lesser appleworm, *Grapholitha prunivora*	Bloom to harvest	Use wing traps baited with specific sex attractant; hang 6 ft. high on limb at outer edge of canopy. 1 trap per 5 acres, minimum of 2 traps per orchard. Check twice weekly. Traps indicate moth presence and timing. Lesser appleworm is a relatively new late-season pest of apples in Illinois; the late summer generation is most damaging. Apply cover spray at peak flight in orchards where moths are captured.
Dogwood borer, *Synanthedon scitula*	May - Sept	Use wing trap baited with sex attractant. Optimum trap density and placement not yet defined; use in manner similar to traps for peachtree borer. Traps indicate presence and timing of moth flight. Dogwood borer attacks graft unions on dwarf and semidwarf trees. Flights are usually greatest May - July.
Vegetable Pests		
Diamondback moth, *Plutella xysotella*	Early head formation to harvest in crucifers	Use wing traps baited with specific sex attractant. Hang from stake at level even with top of crop. Use 1 trap per 5 acres and a minimum of 2 traps per field. Sample for eggs, larvae, and defoliation beginning 1 week after first moths are trapped.
Cabbage looper, *Trichoplusia ni*	Early head formation to harvest in crucifers	Use wing traps baited with specific sex attractant. Hang from stake at level even with top of crop. Use 1 trap per 5 acres and a minimum of 2 traps per field. Sample for eggs as soon as moths are captured or sample for larvae and defoliation 1 week later. Pheromone traps also can be used to detect this insect in other vegetables such as tomato, potato, greens, lettuce, etc. Place traps in these crops May through September or when harvestable tissues (fruits, edible leaves, etc.) are present.

PEST	TRAPPING PERIOD	INSTRUCTIONS, INTERPRETATION, COMMENTS
European corn borer, *Ostrinia nubilalis*	During silking and kernel fill in sweet corn, during fruit formation in peppers, and during pod set in snap beans	No thresholds have been established for the use of sex attractants in water pan traps. Ultra-violet light traps operated in the vicinity of vegetable fields indicate treatment needs according to the following guidelines: Peppers - treat when counts exceed 10 moths per light trap per night; Sweet corn (for processing) - treat when counts exceed 50 moths per light trap per night; Snap beans - treat when counts exceed 25 to 50 moths per light trap per night and more than 300 heat units (10 to 14 days) remain before harvest. Consult individual processors for specific guidelines
Corn earworm, *Heliothis zea*	Before and during silking in sweet corn	Use large cone-shaped traps constructed of wire or plastic mesh ("Heliothis traps"). Position on stake so that bottom of trap is 4 to 6 ft. above soil. Place near corn fields that are just beginning to silk. Threshold for treatment of fresh market corn estimated at 5 moths per trap per day; threshold for treatment of processing corn estimated at 10 moths per trap per day.
Variegated cutworm, *Peridroma saucia*	When fruit is forming in tomatoes	Use wing trap baited with specific sex attractant; hang from stake at level even with top of crop. 1 trap per 5 acres; minimum of 2 traps per field. Check twice weekly. Traps indicate moth presence and timing for additional sampling for larvae and damage. No threshold based on moth counts in traps has been established.
Squash bug, *Anasa tristis*	When squash is producing runners	In home gardens, place boards on soil near squash plants. Squash bugs gather under the boards during the night and can be killed the next day. (Remove dead leaves and mulches around squash plants to reduce other shelter.)
Slugs, *Agriolimax reticulatus* and others	Throughout the growing season	For home gardens and similar plantings, shallow dishes (pitfall traps) of beer or a fermented mixture of water, sugar, flour, and yeast attract and kill slugs. Set dishes into soil in areas where slug damage is evident; dispose of slugs and freshen bait daily. Commercial baits for slugs contain a feeding attractant and toxicant.
Lawn and Turf Pests		
Sod webworms, *Crambus* spp. and others	June - Sept	Use ultraviolet or fluorescent light traps to determine presence and timing of moth flights. Check daily. Control decisions are based on subsequent sampling of turf; threshold estimated at 2 to 4 larvae per sq. ft. of turf.

PEST	TRAPPING PERIOD	INSTRUCTIONS, INTERPRETATION, COMMENTS
Cranberry girdler, *Chrysoteuchia Topiaria*	June 15 - Aug 15	Use wing traps with specific sex attractant; hang 1 to 3 ft. high on stake in lawns or turf. Use in areas where this pest has caused damage in previous years. Traps indicate presence and timing of moth flights and indicate need to sample turf for larvae and damage.
Bluegrass billbug, *Sphenophorus parvulus*	April - June	Use pitfall traps (2- to 3-inch diameter cups set into the soil so that the lip is level with the soil surface) containing a small amount of mineral oil or vegetable oil. Place 2 to 4 traps in lawns with histories of billbug damage to determine overwintering survival and likelihood of turf damage. No thresholds have been established. (This pest is most prevalent in Illinois around the Chicago and St. Louis areas.)
Japanese beetle, *Popillia japonica*	June - Sept	Can- or bag-type traps baited with a mixture of sex and feeding attractants can be used to indicate beetle presence or for mass trapping. Hang traps 3 to 5 ft. high on stakes; do not place traps adjacent to adult beetles' host plants because increased feeding damage may result. For mass trapping, use 1 to 2 traps per acre on golf courses to reduce beetle numbers and egg laying (to reduce subsequent damage to turf caused by larvae). Where beetles are numerous, mass trapping is not likely to provide adequate control of adult feeding on foliage. Where populations are low, traps placed several yards away from host plants can remove enough beetles to substantially reduce feeding on foliage or flowers. (In Illinois, Japanese beetle populations are greatest along the eastern edge of the state, especially in Iroquois and Lake counties.)
Pests of Woody Ornamentals and Shade Trees		
Japanese beetle, *Popillia japonica*	June - Sept	See **Lawn and Turf Pests**.
Lilac borer (Ash borer), *Podosesia syringae*	Late May - early June	Use wing traps with specific sex attractant; hang from branch of host tree (lilac or ash). Check twice weekly. Traps indicate dates of moth flight and allow accurate timing of insecticide applications to ash. Control in lilac is accomplished by pruning.
Peachtree borer, *Synanthedon exitiosa*	May - Sept	Most important monitoring period is from mid May through June. Use wing traps with specific sex attractant; hang 3 ft. high on trunks of host trees (purpleleaf plum and flowering cherry). Traps indicate dates of moth flight and allow accurate timing of insecticide application.

PEST	TRAPPING PERIOD	INSTRUCTIONS, INTERPRETATION, COMMENTS
Viburnum borers, *Synanthedon viburni* & *S. fatifera*	Mid-May - mid-June	Use wing traps with specific sex attractant; hang traps from branches of viburnum. Check twice weekly. Traps indicate dates of moth flight and allow accurate timing of insecticide sprays.
European pine shoot moth, *Rhyacionia buoliana*	Late May - early July	Use wing traps with specific sex attractant; hang traps from branches of host trees (several pines). Check twice weekly. Traps indicate dates of moth flight and allow accurate timing of insecticide sprays.
San Jose scale, *Quadraspitiotus perniciosus*	May 1 - Sept	Use tent traps (from Trece, Inc.) with specific sex attractant; hang on limbs of host plants. Check twice weekly. Traps indicate dates of male flights; crawler activity begins 2 to 4 weeks later. Where pheromone traps capture adult male scales, use bands of black electrical tape around twigs and branches to detect scale crawlers (immatures). Insecticide applications should be applied when crawlers are active (often 2 to 4 weeks after males were first captured in pheromone traps).
Fall cankerworm, *Alsophila pometaria,* and Spring cankerworm, *Paleacrita vernata*	October for fall species; late February for spring species	Apply tanglefoot or similar sticky material to paper bands wrapped tightly around tree trunks to trap and kill ascending cankerworm moths (females are wingless). Leave traps in place for 6 weeks after the starting dates indicated.
Slugs, various species	Throughout the growing season	See **Vegetable Pests.**
Gypsy moth, *Lymantria dispar*	July - Aug	Delta (triangular) traps with specific sex attractant are hung from branches of trees and shrubs. Trapping is done by government agencies to detect the spread of this pest into Illinois. Larval control programs or mass trapping programs are conducted the year following initial detections in an area. Individual operation of traps for gypsy moth usually is discouraged.
Smaller European elm bark beetle, *Scolytus multistriatus*	April 1 - Aug 20	For mass trapping, use aggregation pheromones on large panels attached to telephone poles around the perimeter of a protected area in which bark beetles and dutch elm disease are controlled by sanitation. Traps used in this manner are intended to attract beetles away from American elm. Beetle flights are greatest in spring.
Greenhouse Pests		
Greenhouse whitefly, *Trialeurodes vaporariorum*	Continuous	For monitoring or mass trapping, use yellow sticky panels; place on benches or beds at the same height as foliage. Use 2 to 4 traps per range to detect whitefly infestations; use 1 trap for every 3 to 4 linear ft. of bench or bed for mass trapping.

PEST	TRAPPING PERIOD	INSTRUCTIONS, INTERPRETATION, COMMENTS
Leafminers, several species, and fungus gnats, several species	Continuous	Yellow sticky panels used against whiteflies also capture leafminer adults and fungus gnats. Yellow panels indicate the presence of these pests but are not recommended for mass trapping.
California red scale, *Aonidiella aurantii*	Continuous	Use tent traps (from Trece, Inc.) with specific sex attractant; place near foliage of susceptible plants (for example, hibiscus, many woody plants). Traps indicate presence of scale infestation but do not indicate density or aid significantly in timing insecticide application.
Stored-Product Pests		
Indianmeal moth, *Plodia interpunctella*, and related species (Mediterranean flour moth, raisin moth, almond moth, and meal moth)	Continuously in heated warehouses and food processing plants; April-Oct in grain bins	Use wing traps with sex attractant; a single attractant is effective for all species listed. Hang traps in bin headspace or from shelves, walls, or ceilings of warehouses and processing plants. Traps indicate pest presence; spring trapping in grain bins signals the start of seasonal activity and invasion of the bin. No thresholds have been established for control decisions; however, raw grain that will remain in storage for more than 4 to 6 weeks after moths are detected in the spring should be "topdressed" with an insecticide to prevent infestation.
Angoumois grain moth, *Sitotroga cerealella*, Warehouse beetle and Khapra beetle, *Trogoderma* spp., Red and Confused flour beetles, *Tribolium* spp., Cigarette beetle, *Lasioderma serricorne*, and Lesser grain borer, *Rhyzopertha dominica*	Continuous in heated warehouses and food processing plants; April-Oct in grain bins.	Use wing traps for flying insects; use flat corrugated paper traps (Storgard traps, Trece, Inc.) or cylindrical pitfall (probe) traps to detect insects on or in grain or other commodities. Specific traps are available for cigarette beetle, *Tribolium* spp., and *Trogoderma* spp. Specific attractants are available for the species listed. Traps indicate pest presence; no thresholds for control decisions based on trap captures have been established.
Several species of stored-product beetles	Continuous in heated warehouses and food processing plants; April-Oct in grain bins	Use flat, corrugated paper traps (Storgard) baited with feeding attractants (oat and wheat germ oils) on grain surfaces, shelves, floors etc. to detect stored-product beetles. Use unbaited cylindrical pitfall traps (probe traps) in warm grain to detect infestations of most beetle pests. Use at least 3 traps per bin, with one or two placed in spout lines; leave traps in place 3 to 4 days before removing to inspect.

PEST	TRAPPING PERIOD	INSTRUCTIONS, INTERPRETATION, COMMENTS
Stored-product pests that are attracted to light	Continuous in heated warehouses and food processing plants	For mass trapping, use electrocuting light traps with ultraviolet bulbs. Place traps in dimly lit areas not visible from outdoors (to avoid drawing in additional pests). See Gilbert (1984) for details on placement. Light traps with collection pans (not electrocutors) can be used in similar locations to monitor pest presence. Stored-product pests attracted to lights include Angoumois grain moth, black carpet beetle, cigarette beetle, drugstore beetle, Indianmeal moth, merchant (not sawtoothed) grain beetle, red (not confused) flour beetle, and warehouse beetle.
Livestock Pests		
House fly, *Musca domestica*	Throughout the summer	For mass trapping, jug-type traps baited with raw meat ("stinky traps") or with a specific attractant capture many flies but often do not substantially reduce local populations. Insecticidal baits containing sugary attractants help control fly populations in and around livestock facilities; place these poison baits only where livestock, pets, and children do not have access. Sticky fly strips can reduce fly numbers in small closed areas such as milking rooms and farm offices. If a trap is to reduce house fly populations outdoors, many traps must be used (specific numbers undetermined). For all fly baits and traps, effectiveness should be judged by the remaining fly population, not by the number of flies killed.
Stable fly, *Stomoxys calcitrans*	Throughout the summer	For monitoring or mass trapping, use alsynite panels (Olson Products) coated with adhesive. Place traps 2 to 4 ft. high on stakes. Use 3 or 4 traps per feedlot for monitoring; trap density for effective mass trapping has not been determined. The effectiveness of these traps for substantially reducing stable fly populations in and around feedlots is not well-established.
Horn fly, *Haematobia irritans*	May 1 - Sept 30	For mass trapping, use walk-through traps constructed of lumber, screen, and canvas; see Hall et al. (1987a) and Meyer et al. (1988) for plans for the construction of this trap. Place traps in a gate that cattle must pass through daily. The walk-through fly trap provides 50 to 70% reductions in horn fly infestations on pastured cattle.
Horse flies, *Tabanus* spp. and others	June - Sept	For mass trapping, use canopy traps or box traps; see Hall et al. (1987b) for information on construction. Horse flies are attracted to the dark silhouettes of these traps. Trap density for effective mass trapping has not been determined; use several traps in loafing areas. Although the overall effectiveness of canopy or box traps for substantially reducing horse fly numbers has not been well established, no other effective controls have been identified.

PEST	TRAPPING PERIOD	INSTRUCTIONS, INTERPRETATION, COMMENTS
Household Pests and Nuisance Pests		
Cockroaches, several species	When infestations develop	Use sticky board traps along baseboards in protected areas to detect roach infestations. Foods or dead cockroaches on the traps may make them more attractive. Small jars or cans with a 1-inch wide ring of petroleum jelly around the inside of the rim also can be used as traps; place upright along baseboards. Use baits such as beer-soaked bread, banana slices, raisins, or a mixture of dehydrated potatoes, sugar, and water to attract German cockroaches. Sticky boards and jar traps provide some control of roach populations but are intended primarily for monitoring. "Traps" containing hydramethylnon (Maxforce and Combat) are actually bait stations for use against German cockroach; these bait stations are attractive to roaches and very effective for control.
Ants, several species	When infestations develop	Commercial ant traps or bait stations lure ants to an insecticide. Sweet baits are attractive to carpenter ants and pavement ants; pharaoh ants are attracted to mint jelly and other sweet and grease baits. Place traps or bait stations on ant trails but out of reach of children and pets.
Earwigs, including *Forficula auricularia* and other species	When infestations develop	Use 1-ft. lengths of garden hose or rolled newspaper placed in areas where earwigs have been seen. Earwigs enter these shelters at night and can be collected and killed the next day. These traps can be used to monitor earwig infestations (to determine the effectiveness of an insecticide treatment, for example) or to provide some degree of direct control.
Yellowjackets, *Vespula* spp. and others	Summer and early autumn	Commercial traps sold for mass trapping contain N-methyl-valerate as an attractant. Homemade traps can be made by suspending a dead fish or fish-flavored cat food over a dish pan of water containing several drops of vegetable oil, mineral oil, or detergent. Wasps that take the bait become overweighted, drop into the water, and drown. Place traps several yards from main recreation areas. Although these traps kill many wasps, their effectiveness in reducing local populations is variable. Minimize yellowjacket annoyance by tightly covering garbage containers and keeping food and drink containers closed as much as possible during picnics, etc.
Stable fly, *Stomoxys calcitrans*	Summer	See **Livestock Pests**. For mass trapping, use alsynite panels (Olson Products) coated with adhesive. The effectiveness of these traps in reducing stable fly numbers is variable. For picnic areas, campgrounds, and beaches where stable flies breed in shoreline debris, use several traps (specific numbers undetermined) placed 3 to 4 ft. high on stakes.

PEST	TRAPPING PERIOD	INSTRUCTIONS, INTERPRETATION, COMMENTS
House fly, *Musca domestica*	Summer	See **Livestock Pests**. For mass trapping, use sticky fly strips indoors. Strips that have already captured a few flies and strips that contain pictures of flies are most attractive. Outdoor jug-type traps such as those baited with raw meat ("stinky traps") or a specific house fly attractant usually capture many flies but often do not reduce local house fly numbers substantially.
Various insects attracted to light	Summer	Electrocuting light traps and similar devices that attract insects to ultraviolet or fluorescent light kill many night-flying insects (pests and nonpests) but do not reduce pest densities in outdoor (lawn) uses. See **Stored-Product Pests** for information about the use of these traps in warehouses and food processing facilities. Placing outdoor lighting away from entrances and windows minimizes insect concentrations around these locations and reduces insect entry into buildings.

Table 2. Developers, Manufacturers, and Distributors of Insect Attractants, Traps, and Related Supplies (Additional companies produce attractants and traps; no endorsement or discrimination is intended by the listing presented here.)

Companies specializing in pheromone identification and formulation

Bedoukian Research, Inc.
Finance Drive
Danbury, CN 06810

Bend Research, Inc.
64550 Research Rd.
Bend, OR 97701

Frank Enterprises, Inc.
700 Rose Avenue
Columbus, OH 43219

Provesta Corporation
14 C4 Phillips Building
Bartlesville, OK 74004

Distributors (retailers) of attractants, traps, and supplies

Dewill, Inc.
61 S. Herbert Rd.
Riverside, IL 60546

Great Lakes IPM
10220 Church Rd., NE
Vestaburg, MI 48891

Insects Limited, Inc.
Jessup Blvd.
Indianapolis, IN 46280

Iselin and Associates
4520 S. Juniper
Tempe, AZ 85282

Pest Management Supply Co.
P.O. Box 938
Amherst, MA 01004

Manufacturers of attractants and traps

AgriSense
4230 West Swift, Suite 106
Fresno, CA 93722

Biocontrol Ltd.
538 I Street
Davis, CA 95616

Consep Membranes, Inc.
P.O. Box 6059
Bend, OR 97708

Grain Guard
205 Legion Street
Verona, WI 53593

Heron Environmental Company
Aberdeen Road
Emigsville, PA 17318

Ladd Research Industries
P.O. Box 1005
Burlington, VT 05402

Olson Products
P.O. Box 1043
Medina, OH 44258

Pherotech Inc.
1140 Clark Drive
Vancouver, British Columbia
Canada V5L 3K3

Reuter Laboratories
8450 Natural Way
Manassas Park, VA 22111

Scentry, Inc.
P.O. Box 426
Buckeye, AZ 85326

Trece, Inc.
635 S. Sanborn Rd., Suite 17
Salinas, CA 93901