A PRACTICAL RESEARCH DIGEST FOR TURF MANAGERS

TurfGrass TRENDS

Volume 6, Issue 12

December 1997

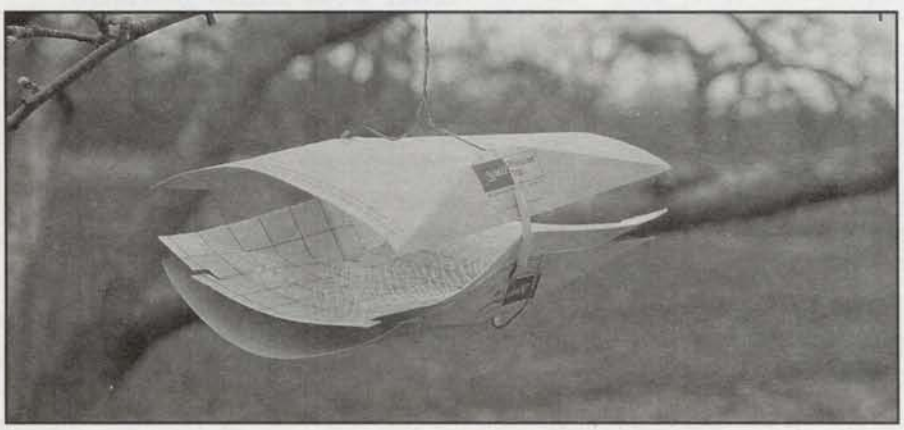
Use of Pheromones in Turfgrass IPM Programs

By Michael G. Villani
Cornell Univcersity

There is hardly a turfgrass manager in a state east of the Mississippi River who has not seen a Japanese beetle pheromone trap hanging from a tree or post in mid-summer. These traps are often overflowing with adult Japanese beetles, and for this reason turf managers, landscapers and homeowners are often convinced that these traps helped to reduce feeding damage of the adult beetles on their ornamental plantings and also help to reduce the number of Japanese beetle grubs that will invade and damage their lawns in the fall of the year. Is this a reasonable assumption? My goal in this article is to address this question. I will describe what pheromones are and why they are important to the insects that produce them, next I will outline possible uses (and misuses) of pheromones in turfgrass pest management programs, and finally, I will review the steps required to develop a synthetic pheromone for commercialization.

What Are Pheromones?

Pheromones are chemical signals that are released by one individual of a species and stimulate a reaction in other individuals of the same species. Insects of the same species can communicate with one another by emitting



Wing trap used for many moth species, including black cutworm adults.

IN THIS ISSUE

AN ADVANSTAR ★ PUBLICATION

TurfGrass TRENDS •7500 Old Oak Blvd. • Cleveland, OH 44130-3369
Phone: 440-243-8100 • Fax: 440-891-2675 • e-mail: knoop@mt-vernon.com

TurfGrass TRENDS

Editor, William E. Knoop, Ph.D.
903-860-2239; 903-860-3877 (fax)
knoop@mt-vernon.com

Production Manager
Linda O'Hara
218-723-9129; 218-723-9576 (fax)
lohara@advanstar.com

Circulation Manager
Karen Edgerton
218-723-9280

Layout & Production
Bruce F. Shank, BioCOM
805-274-0321

Group Editor
Vern Henry

Group Publisher, John D. Payne
440-891-2786; 216-891-2675 (fax)
jpayne@advanstar.com

CORPORATE OFFICE
7500 Old Oak Blvd.
Cleveland, OH 44130-3369

EDITORIAL OFFICE
P.O. Box 1637
Mt Vernon, TX 75457

Abstracts: *800-466-8443*
Reprint: *440-891-2744*
Permission: *440-891-2742*
Single copy or back issues:
Subscription/Customer Service
888- 527-7008, 218-723-9477; or
218-723-9437 (fax)

ADVANSTAR HOLDINGS, INC.

Chairman & Chief Executive Officer
Robert L. Krakoff
Vice Chairman
James M. Alic
Vice President, Business Development
Skip Farber
Vice President, Strategic Planning
Emma T. Lewis

ADVANSTAR COMMUNICATIONS

Executive Vice Presidents
Kevin J. Condon, William J. Cooke, Alexander S. DeBarr, Brian Langille, Glenn A. Rogers
VP-Finance, CFO & Secretary
David J. Montgomery
Treasurer and Controller
Adele D. Hardwick

small quantities of chemical substances from their bodies into the air. While in some cases pheromones are single compounds, in many instances an insect pheromone will be a blend of two or more compounds that are produced and released in a specific ratio by the insect. An alteration in either the structure of the individual compounds or the relative amount of any compound in the blend will cause the pheromone to become inactive.

The released compound (or compounds) travel through the air until it is intercepted by sensory organs that sit on the antenna (or possible other body part) of other members of the same species.

Information transmitted through pheromones may include:

- *the presence of a willing individual* (usually a female) advertising her (or his) presence and location to distant members of the opposite sex (usually a male). Pheromones of this type are known as sex pheromones, and are the type most commonly used in pest management programs to monitor or manage pest populations. Japanese beetle traps usually contain the chemical, (R, Z,)-5-(1-decenyl) dihydro-2(3H)-furonone, that mimics the female sex pheromone of this species. Sex pheromones, by definition, attract members of only one sex; standard Japanese beetle traps incorporate two chemical lures the first containing the sex pheromone mimic attracting only male beetles, and the second, a floral lure composed of a mixture of phenethyl propionate, eugenol, and geraniol (3:7:3 ratio), that serves as a feeding lure attracting both male and female beetles.
- *the presence of high quality food or a valuable area to mate or take shelter.* These pheromones, known as aggregation pheromones, are often produced by members of both sexes of a species and will often attract members of both species. Japanese beetle and Green June beetle adults are thought to produce aggregation pheromones at feeding sites but this has not yet been confirmed. Interestingly, there are some species (none described in turf) that produce pheromones, known as anti-aggregation pheromones, that that repel individuals of the same sexes. Anti-aggregation pheromones may reduce the chance that too many insects will feed or lay eggs on the same tree or shrub thereby resulting in a localized food shortage.
- *the presence of danger such as predators or parasites or other unwanted intruders in the area.* These pheromones, known as alarm pheromones, are usually produced by social insects such as bees, wasps, and ants to warn their neighbors that danger is near. This alarm pheromone often causes these insects to mass and attack the intruder in protection of their nest or hive. Aphids such as the greenbug are also thought to produce an alarm pheromone that alerts their nearby relatives to flee from predators such as ladybird beetles.

Uses of Pheromones in Turf Pest Management

Pheromones have been used in a number of programs for managing turfgrass pests. Most often, they aid in the detection of exotic (foreign and introduced) or endemic (native and established) pests; there is also great interest in using pheromones to manage rather than monitor pests by trapping a large portion of the pest population or flooding the landscape with synthetic pheromone to confuse or disrupt the normal mating behavior of a pest population.

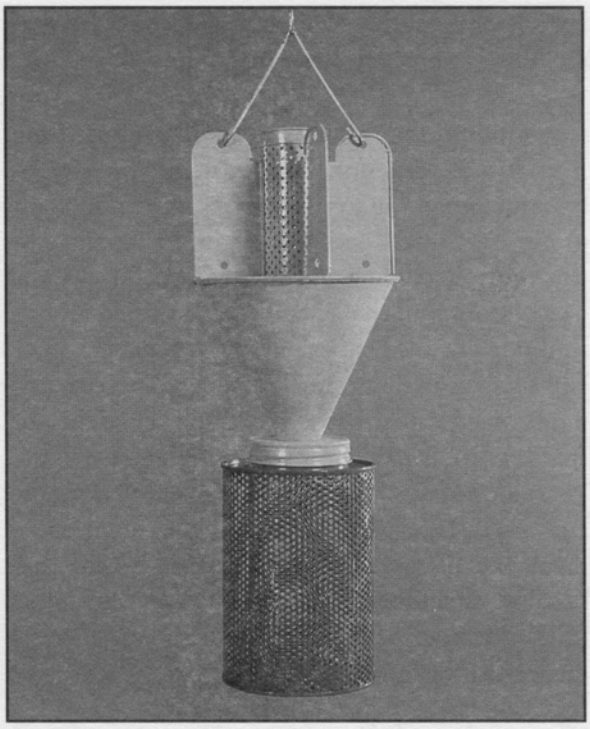
Monitoring - Pest detection requires a sensitive trapping method that provides qualitative information about presence or absence. Pheromone traps provide the most sensitive monitoring system known; they are usually species specific, need no power or maintenance, are not labor intensive, and can be operated by the public. Pheromone traps are a great aid in detecting low numbers of adult insects over considerable distances.

Because pheromones tend to be fairly species specific, they can be used to identify one pest species found in low numbers against a background of high numbers of other insects in the area; for this reason they can be much more use than more general trapping tools such as blacklights in monitoring insects. Such factors as temperature, rainfall, and trap location can affect the effectiveness of a pheromone trap, therefore it is unwise to rely on a single trap or a single trapping date for making management decisions.

Several uses of pheromone traps when used in monitoring programs include confirmation, pinpointing infestation sources, estimating populations, and timing controls.

Confirmation of the presence or absence of insects: Because pheromones will attract individual insects from great distances they are important tools in discovering potential insect pests invading from other areas, foreign or domestic, before they become established and build to sufficient numbers to cause economic damage.

A good example of the use of pheromones for determination of the geographic distribution of an introduced pest species involves the exotic pest, the oriental beetle. Oriental beetles were first collected on the US mainland in 1920 (New Haven CT) having presumably been imported directly from Japan in infested balled nursery stock. Oriental beetles do little if any adult feeding, spending most of their time hiding in the grass and thatch. The absence of readily apparent adult feeding damage greatly reduces the chance that a casual observer will notice a sizable beetle population before significant numbers of eggs are laid in turf and nursery soil.



Pheromone trap used for Scarab, Japanese, and Oriental beetles.

A comprehensive geographic survey for the presence of oriental beetle adult populations through the use of pheromone-baited traps similar to commercial Japanese beetle traps in selected nurseries was undertaken by Dr. Steve Alm and myself in 1994 and completed in 1996.

Ten to twenty-five traps baited with 100 micrograms per septa were used in each state and were monitored at least twice at each location traps from May 1 through August 1. States with positive trap catch at least one year of survey included: Maryland, Massachusetts, New York, Rhode Island, Ohio, New Hampshire, Delaware, Connecticut, New Jersey, Tennessee (probably not established), West Virginia (probably not established),Virginia, and North Carolina. States with negative trap catch included: Georgia, Kansas, Kentucky, South Carolina, Maine, Alabama, and California. Although the establishment of oriental beetles was well known in several of the states with positive trap catches, for several states the survey provided the first indications that the oriental beetle had arrived. This information has important consequences for the sale of nursery stock out of those infested areas, and may also allow local erad-

ication of local populations before they become established and spread to surrounding areas.

Pinpointing the source of insect infestations: Introduced pests often arrive in a new site by hitchhiking on the roots or leaves of plants. Many of our exotic pet species arrive in this country by this route (including the Japanese beetle, oriental beetle, European chafer, and Asiatic garden beetle). Additionally, insects hitchhiking on nursery stock and transplanted into residential, commercial, and public landscapes, are often responsible for the spread of these pests over wide geographic regions. Pheromone traps placed in ports of entry, nurseries and newly established landscapes will often document the presences of pest species before they become established and spread from the initial introduction sites. Such introductions are easily managed if documented early.

Estimating the magnitude of insect populations: There is a great temptation to use the number of insects caught in pheromone traps to help predict the size of the developing pest population and the need to treat.

While low trap counts may accurately reflect a year with low pest pressure, the alternative is not true. Because a number of environmental factors are involved in translating high adult populations into economically damaging larval population, pheromone trap counts have never been shown to be a good indication of larva population levels or potential feeding damage.

Improved timing of insecticide application: Pheromone traps can be useful in determining when an insecticide treatment should be made for controlling a damaging pest population by establishing important milestones in the development of a pest population. One good example of this use of pheromones is the trapping of black cutworm moths in the Northeast. In typical years, black cutworms do not survive the cold northeastern winters, instead they migrate to the north from southern states in each spring. Wing traps baited with black cutworm pheromone can help pinpoint when the wave of black cutworm moths arrive in a specific location. Since insecticides are most effective when applied to newly hatched caterpillars, knowing when moths arrive in a location (factoring in the lag time required for eggs to be laid and then hatch) improves insecticide efficacy.

Direct Control of Insect Pests

Direct control of insects with pheromones centers around mass trapping and disruption of mating.

Mass Trapping - Anyone who has seen Japanese beetle traps overflowing with insects might believe that this trapping will translate into less adult feeding damage to ornamental plants in the area, and few Japanese beetle grubs infesting the surrounding turf the following fall. Although the pheromone/floral lure baits will attract large numbers of beetles, many beetles drawn to the trap will be intercepted by attractive host plants in the landscape leading to higher beetle numbers. Mass trapping may be a useful control tactic for an established pest species if large geographic regions are targeted and if a great number of highly efficient traps are used. Mass trapping may also be useful if an introduced pest that has not had a chance to establish in an area is targeted (for example the mass trapping of oriental beetle adults in a nursery or interiorscape in an area with no established beetle population).

Mating Disruption - This approach involves the saturation of the environment with massive amounts of synthetic pheromones so that males and females cannot locate each other to mate. Mating disruption have the best chance for success when the initial pest population is small, there is little chance for immigration of individuals into the target site, the synthetic lure will out compete calling females, and males emerge before calling females thereby reducing the synthetic lure's competition with calling females. These factors are in our favor if we attempt to reduce introduced pests in isolated nursery blocks or greenhouses.

Pheromone Research: Discovery To Commercialization

Studies have confirmed the presence of a sex pheromone in a number of turfgrass insect pests

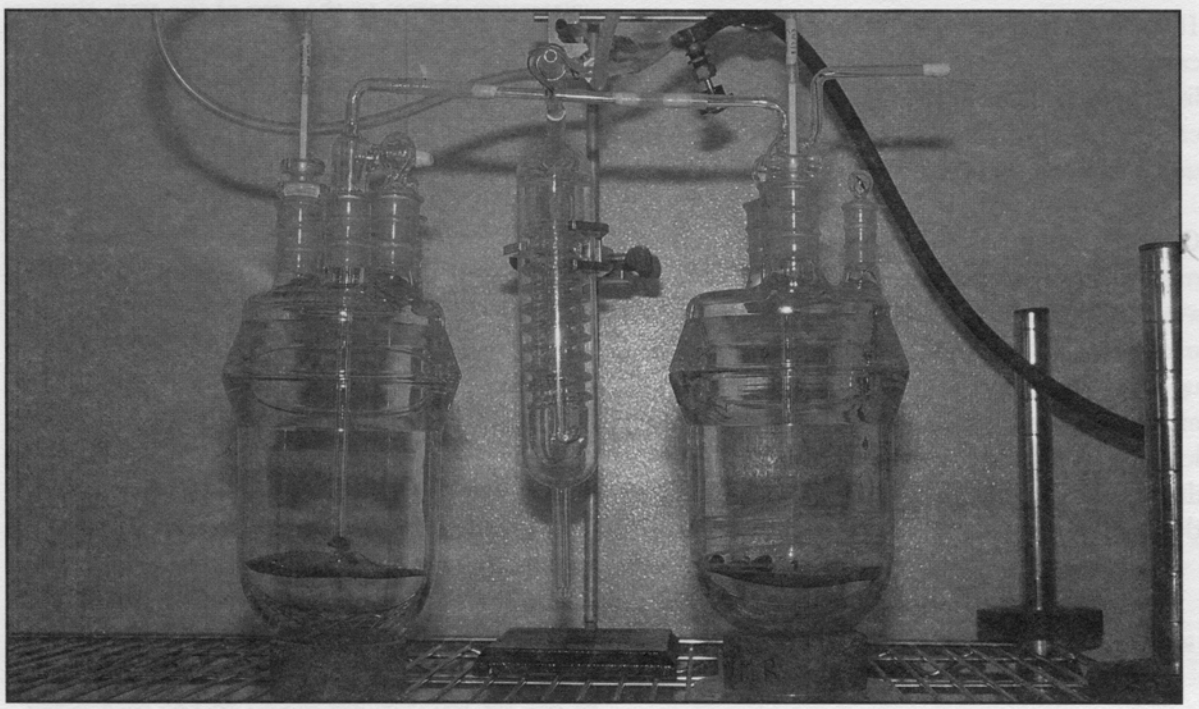
besides the Japanese beetle. These species include: oriental beetles, southern and northern masked chafers, many May and June beetle species, Green June beetles, fall armyworms, black cutworms, true armyworms, and a sod webworm species also known as the cranberry girdler.

Other turfgrass insects are suspected of producing sex pheromones but this has yet to be confirmed by researchers. Although we know that many insect species employ sex pheromones to attract mates, the presence of a sex pheromone is just the first in a long series of steps needed before a synthetic pheromone can be used in a practical pest management program.

These steps include the verification of the pheromone's presence, isolation, identification, synthesis of compounds, determining proper blend ratios in the lab, testing of release rates in the field, optimization of trap placement and design in the field, and finally incorporation of the pheromone into an established turfgrass pest management program. Consider the steps taken in the discovery and commercialization of the oriental beetle pheromone in the northeastern U.S.

Discovery - The discovery of a pheromone usually begins with the study of insect behavior in the field. Insects that appear to be flying in a systematic or controlled manner over turfgrass or around trees and shrubs may be attempting to locate a mate who is releasing a sex pheromone into the air. Searching males often show a distinctive search pattern that includes flying into the wind in a casting pattern as it moves into and then out of the pheromone plume. When close to a calling female, male insects will often fly in a straight line to the female and begin to mate. Calling females (females releasing pheromone) will often have distinctive behaviors to improve the release of pheromone into the environment. Jim Hanula (then at the Connecticut Experiment Station) first observed the typical searching behavior of male oriental beetles on golf course fairways early in 1990.

Confirmation - The next step in the path from discovery to commercialization is experimental proof that a pheromone is present. Jim Hanula and Steve Alm caged virgin oriental beetle females on golf courses that had high population of oriental beetle adults. Females in these cages could not be seen by flying males but any compounds released by the



Laboratory device used to collect pheromones from live female insects.

females would spread down wind. Other traps, were similar in every way but contained dead rather than live female beetles (only live insects emit pheromones). The traps containing live females attracted many more male beetles than did those containing dead females confirming the presence of a sex pheromone.

Isolation, Identification, & Synthesis - The first step in the isolation, identification, and synthesis of a pheromone is to collect the pheromone from calling individuals. Researchers at the New York State Agricultural Experiment Station placed virgin female oriental beetles in closed containers and collected the compounds the female released into the air. Gas chromatography coupled with wind-tunnel assays of male beetles identified the pheromone as a mixture of 7-(Z)- and 7-(E)-tetradecen-2-one (89:11 ratio). Oriental beetle pheromone was synthesized and formulated in synthetic lure incorporated plastic pellets (4-5 mm in diameter) made of polyethylene plastic.

Field Testing - The man-made (synthetic) sex pheromone must be at least as attractive as calling females to be useful in pest management. Field studies conducted on golf course fairways during the summer of 1993 showed that traps baited with 100 µg of synthetic pheromone caught significantly more males than did traps baited with three live virgin Oriental beetle females. All baited traps caught significantly more beetles than did unbaited traps.

Optimization - Although a synthetic pheromone may effectively attract insects to the general area of a trap, optimal trap design and placement will maximize the number of attracted insects that end up safely in the trap. Understanding the behavior of the insect species you are trying to catch is critical for successful trapping. Field studies conducted during 1993, 1994 and 1995 suggested that male oriental beetles attracted to calling females or synthetic pheromone usually walked, rather than flew to the female of pheromone lure. This suggested that traps set at ground-level, rather than hung on stakes or in trees would be more effective at catching beetles. Alm confirmed this by placing pheromone-baited traps a several different heights on golf course fairways and counting the number of males trapped at each height. Those traps placed with the collection funnel at ground level consistently trapped more oriental beetles than did traps at any other height. Trap size and color may also significantly affect trap catch.

Commercialization - For a synthetic pheromone lure to be a commercial success it must be relatively inexpensive to produce, have a long shelf life (not lose potency from the time it is manufactured to when it is sold), remain active in the field for the entire time the insects are active, and provide information to the end user that justifies the purchase price. Synthetic oriental beetle pheromone appears to have characteristics that will encourage commercialization and user acceptance.

Conclusions

While pheromone lures are often very effective in attracting insects to the area of the trap, they are usually much less efficient at predicting the size of the population, or significantly reducing either adult or feeding damage. Much like a power mower or a high-pressure spray rig, pheromones are a tool that may be useful in an integrated turf management program, but the misuse of the tool can often result in more harm than good. Any turf manager who has hung a Japanese beetle trap in, or near, a tree or shrub that is a favorite food of adult Japanese beetles will readily attest to this observation.

Michael G. Villani is Associate Professor Soil Insect Ecology in the Department of Entomology NYSAES/Cornell University, Ithaca, NY.