"When our aircraft tug broke down for the last time, we replaced it with something reliable from John Deere."

E. K. Jones, Jr., President,
Iowa City Flying Service, Iowa

If it weren't for E. K. Jones, Jr., and his John Deere 850 Tractor, a lot of airplanes might never get off the ground.

Thirty times a day, he uses his John Deere to pull airplanes out of the hangars.

"It's a real nice tractor, and I haven't had any trouble with it," says Jones, after 1,046 hours of service.

But things weren't always so easy. Until a couple of years ago, he hauled airplanes with an old aircraft tug that gave him nothing but trouble.

"Every time it broke down, we had problems."

Which explains the feature Jones likes most about his John Deere 850 Tractor.

"It's maintenance free."

Small enough, yet big enough.

When his old aircraft tug finally died, Jones needed more than something reliable. He also needed something that was big enough to pull planes as heavy as six or seven thousand pounds. Yet small enough to be economical to buy and operate.

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It has a compact, water-cooled, 3-cylinder diesel engine that has enough power and stamina to pull airplanes around, day in and day out, year after year.

And because it's a diesel, it's more economical to operate. Which is important to Jones because sometimes he runs his tractor all day long, non-stop.

A better tractor, even for pulling airplanes.

The fact that Jones uses a John Deere Tractor to haul airplanes certainly displays its versatility.

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And E. K. Jones, Jr., and the Iowa City Flying Service plan to be in business for a long time.

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resting spot underneath a leaf's surface. It begins to migrate from the foliage it feeds upon at night to resting locations on the tree's trunk or on signs, treehouses, stone walls, and other ground sites during the day. In the evening, it moves back up the tree.

Bark flaps of burlap or other materials wrapped on a tree trunk make a suitable resting spot and thus a trap for the gypsy moth. Here they can be collected and either killed or monitored. Research on the use of bark flaps for estimating populations, determining larval behavior, and aiding biological controls is being investigated by Wallner of the Forest Service in Connecticut.

Chemicals

Scientists now agree, as do most arborists, that pesticides are only a piece of the puzzle for total gypsy moth control. However, spraying insecticides is still the most thorough method of control and they cannot be ignored at this time to treat the gypsy moth.

If a trapping program in Virginia shows an isolated infestation, the Forest Service uses an intense spray program to wipe it out. According to John Weidhaas, extension specialist in entomology at Virginia Tech, the Forest Service will use Dimilin, an insect growth regulator, because it is highly specific to caterpillars. It is not approved for populated areas. Spraying occurs in the second or third week of May. Hitting the gypsy moth in its early instars is vital for any chemical to give maximum effectiveness. The application of Dimilin has been cut in half under acceptable weather conditions and then sprayed a second time in June.

Many chemicals are available, often limited by state regulations and to licensed applicators. The following chemical insecticides are registered: carbaryl (Sevin), trichlorfon (Dylox), acephate (Orthene), Imidan (a phosphate-type insecticide), Bidrin (a toxic insecticide used by injection), Malathion, and Methoxychlor. Diflubenzuron, (Dimilin), which prevents the gypsy moth from molting, is only registered for forest treatment.

At the Otis methods development center, where Charles Schwalbe directs the research, insecticide screening is a large project. The center screens biological and chemical compounds from industry to determine their toxicity to the gypsy moth.

Schwalbe describes the work like this: "We take registered insecticides and try to define their use patterns. We use the minimum efficient dose to receive the desired control. We improve formulations so they work better, concentrating on microbial insecticides. When you spray one, it doesn't last long; ultraviolet light breaks it down and rain washes it off. This is the main reason for erratic results."

Until recently, Schwalbe says, there has not been the concern of these two factors affecting insecticide residual. Research information has made manufacturers more willing to accept the results. The Otis laboratory has made significant progress with stickers to counter the wash effect

Gypsy Moth Food Plant Preferences

Most Preferred	Intermediate		Least Preferred
OAK	MAPLE	SOURWOOD	ASH
HAWTHORN	BUCKEYE	PINE	HOLLY
PAPER BIRCH	HICKORY	COTTONWOOD	MULBERRY
GRAY BIRCH	RED BUD	CHERRY	YELLOW POPLAR
APPLE	HACKBERRY	HEMLOCK	SYCAMORE
SWEETGUM	DOGWOOD	ELM	LOCUST
TAMARACK	PERSIMMON	SERVICEBERRY	FIR
ASPEN	BEECH	BLACK WALNUT	SPRUCE
WILLOW	MAGNOLIA	SASSAFRASS	RHODODENDRON
BASSWOOD	TUPELO	WITCHHAZEL	MOUNTAIN LAUREL

of rain. Ultraviolet penetration is a tougher problem.

Sterilized males

Another project Schwalbe's team deals with is rearing large quantities of sterile male gypsy moths. Cobalt 60 gamma radiation is used. It is important to get the right amount of radiation at the right development of the gypsy moth.

This research is now in its fourth year and is still preliminary. Last year, the first field tests were done in Michigan and they will be continued there this year. Schwalbe expects that the tests at low level populations will show how well the sterilized males mate and how they move in the field.

FEEDING RESPONSE OF 3rd INSTAR GYPSY MOTH LARVAE TO FOLIAR EXTRACTS OF VARIOUS PLANTS FROM NORTH AMERICA

STIMULANT	NEUTRAL	DETERRENT
DOUGLAS FIR	OLIVE	VIBURNUM
HONEY LOCUST	ROYAL PALM	GUMBO LIMBO
COTONEASTER	ELDER	MANGROVE
FORSYTHIA	SEA GRAPE	EUCALYPTUS
GINKGO	PAW PAW	ANDROMEDA
GIANT SEQUOIA	RASPBERRY	CAMELLIA
DEODOR CEDAR	BALD CYPRESS	LIME
THOMPSON SEEDLESS GRAPE	EUONYMUS	CAJUPUT TREE
CRAPEMYRTLE	WAX MYRTLE	PISTACIO
ALMOND	BLUEBERRY	CALIFORNIA LAUREL

Biological agents

Two entomologists, William Yendol from Penn State and Frank Lewis, principle insect pathologist at the Northeastern Forest Experiment Station, gathered sufficient data from studies to help get *Bacillus thuringiensis (Bt)* registered with the Environmental Protection Agency. After this success, they did the necessary research to register a gypsy moth virus, nucleopolyhedrosis (NPV), named Gypchek. "We did research and development of these microbials for control and utilization in IPM programs for gypsy moth management," says Lewis.

Bacillus thuringiensis, a spore-forming bacteria, comes in many strains, one of which is registered and produced under the names Dipel, Thuricide, and Bug Time. It kills the gypsy moth in its larval stage. When the insect eats the mixture of spores and crystals, the larva's gut is paralyzed. Ultimately, the insect starves to death or the bacteria grows and kills the insect by septicemia, or multiplication of the bacteria in the blood.

"We have mainly tried it (*Bt*) by itself," says Lewis. "We need much more work integrating these things, trying to substitute microbials for pesticides. We present it as an option. *Bt* works better when applied from the ground than the air."

The most devastating disease of the gypsy moth is that caused by the specific nucleopolyhedrosis that affects the larval stages of the insect. It is entirely specific to the gypsy moth. Like *Bt*, NPV is slow acting and harmless to the environment.

An insect becomes infected by eating foliage that has been contaminated with virus-containing polyhedral inclusion bodies (PIB's). The PIB's dissolve in the gut of the insect and release virus rods which first cross the gut wall and then infect blood cells. The disease progresses to the fat body and finally to cells of the integument (outer skin). An infected larva will show signs of the disease by loss of appetite, listlessness, a darkening in color, a moist-appearing integument, and often a tendency to climb upward. Infected larva usually die within 9 to 11 days and hang from foliage of bark in an inverted "V" position.

Dr. Yendol says present research is dealing with different forms of Gypchek and its mode of action. This year it will be studied in an attempt to improve the application technology, including aerial application rates, dosages, and its most effective ways to treat egg masses. Work focuses on incorporating the virus into pest management with pheromones, parasites, and insecticides.

Infectious diseases caused by bacterial pathogens are also important in gypsy moth regulation. Unlike NPV, which infects blood cells, these bacteria simply multiply in the fluid portion of the hemolymph (blood) and kill larvae either through the production of toxic substances or by depleting the insects of nutrients. Of these naturally occurring bacteria, *S. faecalis* and *S. marcescens* are probably the most effective in killing gypsy moth larvae.

Parasites

Another program to halt the rampage of gypsy moth is occurring in New Jersey under APHIS control. William Metterhouse is running the program which involves field evaluation and monitoring of gypsy moth parasites. Started in 1963, the field and laboratory studies have helped to introduce seven parasites and one predacious beetle into the population in New Jersey and New England.

Several species of small wasps attack the various life stages of the gypsy moth. One of the

Continues on page 24

Gypsy Moth *from page 23*

most common species, *Ooencyrtus kuwanai*, is an egg parasite that can attack 30 percent of an egg mass and up to 90 percent of a small egg mass. *Apanteles melanoscelus* and *Phobocanpe disparis* wasps attack the larval stages. Another wasp, *Brachymeria intermedia*, stings the gypsy moth pupae but is most effective when gypsy moth populations are at defoliating levels.

Several fly parasites infect the gypsy moth. The most promising, according to Metterhouse, is *Parasetigena silvestris*. *Compsilura concinnata* attacks insects on more than 200 of their hosts. *Blepharipa pratensis*, another fly, lays its eggs on leaves and the gypsy moth caterpillar eats the eggs when it eats the leaves. A predacious ground beetle, *Calosona sycophanta*, which was imported from Europe, attacks both the larvae and adult gypsy moth.

"Parasites provide another regulating factor," says Metterhouse."The augmentation of parasites on low gypsy moth populations has become more important. More research is ongoing and all parts of the USDA are cooperating. An example of the cooperation between APHIS-SEH-Forest Service is the evaluation of parasites for vectoring microbial diseases to increase effectiveness of natural controls.

Predators

The gypsy moth's parasites are usually smaller than the host they attack and develop with a single individual. Predators usually are larger than their prey and consume many host insects during the course of their life. They are very active, live longer, and may prey upon a variety of insects, depending on what is available.

According to Harvey Smith with the Department of Agriculture's Northeast Forest Experiment Station in Hamden, Connecticut, the importance of predators has probably been underestimated because they consume their prey quickly and leave few if any remains. Woodland mammals can consume large numbers of gypsy moth larvae and pupae in forested areas. Some mammals eat only one life stage of gypsy moth, while others may eat as many as three.

Some mammalian predators of the gypsy moth include the white-footed mouse, shrews, chipmunks, moles, and squirrels. Shrews, which are often mistaken for mice, are voracious insect feeders that consume their weight in prey each day. Unfortuantely, mice and shrews are probably not important as predators in suburban settings because they are eliminated by domestic animals such as the common cat and because their natural habitat, forest litter, is frequently destroyed.

Many species of birds have been observed feeding on gypsy moth larvae or adults. Nuthatches, chickadees, towhees, vireos, northern orioles, catbirds, robins, and blue jays are probably more important in sparse gypsy moth populations. Cuckoos and flocking species such as starlings, grackles, red-winged blackbirds, and crows may be attracted to areas where the gypsy moth exists in large numbers.

Other factors

Numerous factors, often difficult to measure, contribute to the control and spread of gypsy moth. Ripe temperatures can trigger heavy infestations of the gypsy moth. An early thaw proceeded by severe freezing could reduce populations. Unfortunately for residents of the Northeast and surrounding areas, conditions appear healthy for the gypsy moth in 1981 and preliminary studies show this year may be the highest population ever.

Awareness of all facets of the gypsy moth—its life cycle, habits, and controlling agents—can make a major difference in a preventative rather than protective program. According to Dr. Cameron, "As the insect moves down through the south and west and the initial defense is beyond us, we seem to get into the situation in which we hope it doesn't get too bad. Then populations build up and we try to protect the areas threatened. It becomes a reactive program that develops over the years rather than a true management program with emphasis on prevention."

"How long it remains, no one is certain," says Dr. Lewis. "It is a cyclical insect in Europe; it subsides and reappears in Europe every seven to eight years. These cycles appear to be climate related." Barring dramatic changes in the climate, Lewis expects the insect to be at least as serious a problem in 1982.

"It will probably take more resources than we have now," Lewis says. "All our tools and tactics are being researched to collectively and selectively use for control. Our past experience of a single control has not solved the problem. Hopefully, we will have a longer term management."

Nobody is deluding himself with optimistic predictions. Dr. Cameron says, "We are a long way from broadly managing the gypsy moth in the U.S. This is part of the challenge and part of the work."

Dr. Schwalbe says, "The gypsy moth is a tremendously cosmopolitan insect. It occurs under such a variety of situations that there is just no way that within the extremely near future we will have the means to control it."

If anything positive has arisen from this devastating insect, it could be that government and industry are working together to solve the problem. The concept and activity of pest management has come alive and may soon be a household word. The gypsy moth could be the rallying force that makes IPM work. **WTT**

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THE GROWING ROLE OF PHEROMONES: FROM INDICATOR TO CONTROL METHOD

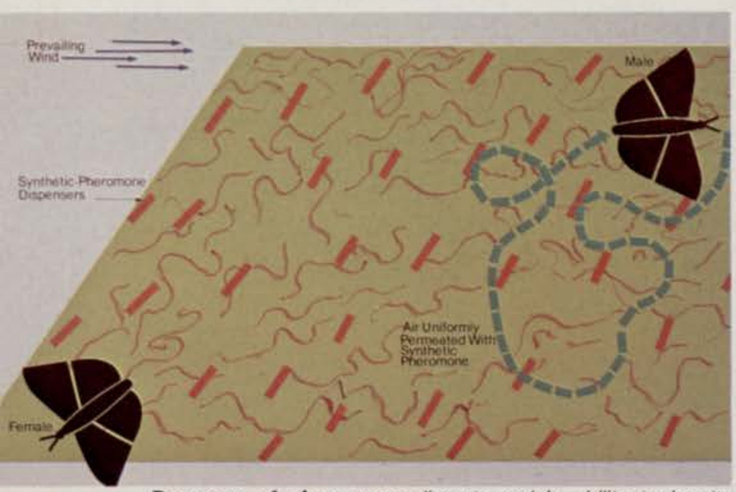
By Ian Weatherston, Technical Director, Albany International, Needham Heights, Massachusetts. Address delivered to the National Arborist Association Annual Meeting in February 1981.

Increased ecological awareness by the public has encouraged the commercial development of alternatives to some chemical toxins as a means of controlling insect pest species. Among the alternatives which show promise are sex pheromones.

The attractiveness of female moths to males of the same species has been known since the 18th century but it was not until 1959 that the word pheromone was coined and defined as, "A chemical message carrier between members of the same species, and beneficial to that species."

Organisms other than insects possess pheromones, but insect pheromones are our primary interest. Subsequently, pheromones were categorized according to their function, leading to "trail pheromones", "aggregation pheromones", "alarm pheromones", "territoriality pheromones" and "sex pheromones". The promise offered by sex pheromones as an alternative to insecticides is that they could be used in insect control without detrimental side effects on nontarget organisms and the ecosystem, and this has been the major driving force behind much pheromone research.

The first sex pheromone was identified in 1959, and today pheromones or attractants are known for more than 350 species of Lepidoptera belonging to 29 families (there are of course many more pheromones known—belonging to the Coleoptera, Hymenoptera and Diptera). The pheromones of the Lepidoptera are generally blends of relatively simple chemicals whose subtlety is a factor in maintaining species integrity. Within this blend components may be identified as causing long range orientation while others are classified as close range pheromones.



Presence of pheromone disrupts male's ability to locate female.

Although improved instrumentation has lessened the difficulty in isolating and identifying pheromones, and although there is frenetic activity in the field testing of pheromones, the commercialization has only recently begun to pick up momentum.

As you well know, there are two steps involved in pest insect population management. There is monitoring or surveying and there is the control or regulation of the numbers to an acceptable economic level. In both steps pheromones can play an important part. The Albany International system is used for control through mating disruption. Normally the female releases her pheromone, and the plume is carried downwind. A male can orient to the plume and find the female. However, when the air is permeated with the synthetic pheromone, the male is unable to find the female. For this strategy to succeed, the synthetic pheromone must be disseminated over a period of time minimally equal to the duration of the adult stage of the target pest. Our system used to obtain this controlled release is based on hollow fiber technology; that is, the pheromone in the fiber diffuses out of the open end at a steady rate. The rate of release is dependent on the internal diameter of the fiber, and of course, on the environmental temperature.

In 1980 we treated 66,500 acres of cotton in the United States and South America by this disruption technique for control of the pink bollworm. The material was aerially applied, with an average of three applications. The rate of application averaged 20 grams per acre of formulation which is equivalent to 1.52 grams of synthetic pheromone per acre. Other insects against which products have been commercially used with success are the western pine shoot borer in the Pacific Northwest and the tomato pinworm in Mexico. Development of application methods is also an integral part of creating diversity for the system; besides aerial application, hand and ground application equipment are available.

For monitoring, the pheromone system is composed of a trap and a lure. Information obtained is (a) presence of specific pests, (b) population density (although this is a very complex question), and (c) the determination of peak emergence on which to base a subsequent treatment. Traps come in a variety of shapes and types. Sticky traps include the delta trap, the ice-cream carton trap, and the wing trap. Advantages of

Continues on page 30

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Pheromone *from page 28*

these types of traps are that they are commercially available, easily handled, cheap, and disposable. The negative side is the trap's efficiency to catch a moth decreases as the number of moths caught increases.

Another type of trap is the wire cone trap. In this design the males are trapped in the upper portion and are unable to find their way out. The non-overloading trap is one in which the moth is attracted into the top portion of the trap, knocked down, by say vapona, and is collected in the lower portion.

The number of captures rises to a point where trap effectiveness drops.

The lure or pheromone dispenser used with the trap must release the pheromone at the desired rate. Generally when the concentration of the bait is increased, the number of captured insects also rises to an optimum point, beyond which the number of captures decreases. Materials which have been used as bait include rubber septa, polyethylene vial caps, beem capsules, dental wicks, cigarette filters, polymer matrices, and a lure composed of a parallel array of hollow fibers. The rate of release of hollow fiber arrays is dependent on the diameter of the fiber and also on their number.

Three insects of interest are the gypsy moth, the Japanese beetle, and clearwing borer. Although Albany International, at this time, does not manufacture products for the consumer market, we believe that this year several gypsy moth products will be introduced for sale to the home owner. It is highly probable that they will be part of a system which will also contain a killing agent. We do sell, however, a monitoring system for this insect. Pheromones are classified as biorational pesticides and as such, when used for insect control, must be registered by the Environmental Protection Agency. For strictly monitoring purposes registration is not required. However, trap and lure combinations purporting to be a control system require a registration.

A product which is commercially successful is aimed at controlling the Japanese beetle. It is known as Bag-A-Bug. This is not an Albany International product but it does use as the attractive source a combination of the sex pheromone and the floral scent.

The 1980 national insect pest priority list of the National Arborist Association identifies several borers, including dogwood borer, rhododendron borer, ash borer, peach tree borer, and lilac borer, in the top forty pests. The pheromone systems for 52 species of clearwing borers are known. **WTT**