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INSECTS AND MAN

THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION • NEW HAVEN

On Living With Insects

by Neely Turner . . . *Department of Entomology*

INSECTS have been on this earth for at least forty million years. The behavior of primitive peoples indicates that our forebears accepted insects as a part of their surroundings. Primitive man did not know the origin of insects, their means of spread, biology, or susceptibility to control. Later, in his innocence, man attributed sudden visitations of strange insects to a deity. Thus, at the dawn of recorded history an angry God sent a plague of locusts to punish a wicked Pharoah.

We are no longer innocent about insects. Competent entomologists both here and abroad have named most of them, studied their habits, determined their means of spread, made progress in determining what regulates their numbers, and developed ways to avoid damage or to kill them. Thanks to the Russian Uvarov, the Frenchman Faure and the British Johnston, we know how plagues of locusts like those in ancient Egypt develop. We have learned that insects are an integral part of nature, and that an outbreak of insects is the logical result of natural forces. As we understand this, the fear of insects is replaced by respect for them.

We too are a part of nature. We eat oranges, potatoes, fish, and beef. It is just as natural as for an insect to eat them. We build with brick and a mud-dauber makes a nest with clay from the same pit. We cut a pine tree to build a house: carpenter ants excavate the living tree for their home. We store wheat in a granary and meat in a freezer. Squirrels store nuts in their way, and the wasp lays in a reserve of spiders.

The adaptability of insects is beyond question, they have persisted through periods of glaciers, floods, volcanic eruptions, and other disturbances of the last 40 million years. In Connecticut we have at least 10,000 different species of insects, probably more than of all other animals and plants combined. Each species differs from its closest relative: the two cannot cross breed. Each has a relatively short life cycle and a reproductive potential greater than other animals.

We, too, are naturally adaptable. True, we commonly adapt by changing the environment in our favor, which insects apparently cannot do.

Insects are here to stay. Therefore, it is prudent for us to learn to live with them. This reality underlies the research on insects at this Station.

Great progress has been made since economic entomology was established in this country more than a century ago. The period of most rapid development of control with insecticides followed the introduction of DDT about 15 years ago and, shortly afterwards, of the phosphate insecticides. We now have practical control measures for most of our insect pests.

For the first time our entomologists are not working under the pressure of necessity to reduce serious losses. This allows greater emphasis on biological problems as important as the development of insecticides. This issue of FRONTIERS shows the philosophy behind the work, the approach, and some of the results.

From the Director

Basic science has long been a neglected child in the "American way of life." We are a great nation of developers and because we are developers we have become a great nation. Our very success as developers too often hides, however, many of the foundations which underlie our achievements.

Our list of our developments is endless. It covers that gamut from penicillin and DDT to jet engines, diesel engines, and atomic bombs. The key principles for all of these we have imported from abroad. This is epitomized by the greeting which Explorer I gave to Sputnik as they met in orbit for the first time—"Guten Morgen." Explorer I speaks German and so does the diesel locomotive on the 20th Century Limited. Atomic and hydrogen bombs also speak with a strong German accent. The first atomic reactor spoke Italian.

In agriculture, nitrogen fertilizers, DDT, and the "miracle" phosphate insecticides speak German. Bordeaux mixture speaks French and benzene hexachloride speaks English.

I do not mean to say that we have no basic science, only that we are weak in that field. After all, America has fathered Willard Gibbs, Jonas Salk, and Donald Jones.

Basic science is a creative venture that requires intellectual effort of a high order. It flows from the minds of a relatively few men and it flowers generally in a climate of quiet contemplation. I see dozens of folders on the men being considered for staff members here. The hallmark of most of these men is, "He is quiet. He is reserved. He is a little difficult to get acquainted with."

To most Americans such a quiet thinker is an "egghead." He is impractical. He is a theorist in a nation of hardheaded men of action. He is a little difficult to understand. Since his "public relations" are weak, we have tended to neglect him. We have been a little afraid to give him financial support—and besides we are doing all right with the ideas we are importing from Europe.

Bill Mauldin, writing in the New York Times for December 8, 1957, says: "We are the only nation on earth that scorns our eggheads. 'Eager beaver' is a term of derision from kindergarten through life. American kids place a high value on conformity . . . having learned from daddy that the nicest things you can be is 'regular—one of the boys,' and the child who has the guts to stand out in class pays a heavy social penalty."

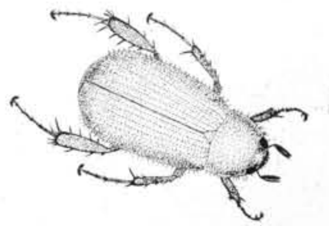
Sputnik has shaken us, clean down to our roots. It provides our practical nation with a practical problem that we can sink our national teeth into. We cannot let the Russians outrun us! What is the answer? "Give us more scientists," we say. "Let us convert our whole school system into a training ground for a new team—a team of scientists who will outsputnik the sputniks."

The school system needs attention, no doubt of it, but it would be folly to convert it so completely to science. The decline of the school system is not really due to the schoolmen. They have struggled desperately against the pressure to convert the schools into a giant boondoggle, teaching the superficial, getting in the little "sell" for this and that, and overlooking the hard facts and philosophy of intellectual importance.

We the people are responsible. We the people have insisted on the snap courses. We the people have dumped our disciplinary problems onto the schools and thereby blocked their opportunity to give basic instruction. We have inoculated our children with disease preventives, but not with the desire to be imaginative and creative.

My story ends with another quotation from Bill Mauldin: "Until kids learn from their elders to respect the man who carries his wealth between his ears as much as the one who drives it around in a glitter of chrome, we're going to get into deeper and deeper trouble."

James G. Horsfall



What Makes an Insect a Pest?

by Richard J. Quinton . . . *Department of Entomology*

Insects in the absence of man are not pests. To be called pests they must compete with man and be destructive, noxious, or troublesome. This does not infer that man is an extra element in the natural community or that he is responsible for the competition. It denotes, rather, a contest for a mutually desired object. The corn earworm feeding upon sweetcorn, which man values, is an acknowledged pest. If the same insect were to infest poison ivy (it does not), then it might feed upon ivy with abandon, and we would be unconcerned.

Of the hundreds of thousands of different insects already known, only a few are pests and most of these, as might be expected, like what we like. These conflicts may be unwittingly or unavoidably aided by man, whose activities often afford varied and repeated opportunities for otherwise unobtrusive insects to become pests.

When the white man arrived in North America, the land was essentially undisturbed. Although the native Indians raised some corn, beans, pumpkins, squash, tobacco, gourds, and sunflowers, their culture was primitive and they had no permanently arable lands. The vegetative cover was mostly an unbroken forest from the eastern seaboard to the central plains. In this situation plants and animals existed in a kind of balance which was maintained by the shifting action of temporarily adverse conditions of the environment.

With permanent settlement based upon agriculture came a gradual change. Cleared fields, permanent although artificial, were used to raise not only those crops adopted from the Indians, but an ever-increasing number of exotic plants; and on these cleared fields some plants previously contained became weeds. With the settlers came plants and with both came insects. Thus, in addition to facing the ravages of adaptable native insects, we have had to cope with a great variety of introduced species.

Not all introduced insects become pests. Many are beneficial or do not compete with man. Others, although potential pests, do not become established in their new situations. Insects as a group are adapted to a wide variety of situations, but all have certain inherent characteristics which limit the particular conditions under which they live. In general, the abundance and potential destructiveness of any insect depends upon its ability to survive and multiply in the face of many adverse forces in its environment.

We are now witnessing in Connecticut the spread of the alfalfa weevil, an insect observed in our State for the first time last year. In many areas where it has become established, this insect is the principal pest of alfalfa, and appearance of the weevil in Connecticut marks a step in the continuing extension of its range. The weevil is quite likely to cause some damage here, and it may be extensive. It remains to be seen, however, whether we will be subject to continuous, heavy attack or whether damage will be infrequent or less severe. The weevil is but one of many insects which feed upon alfalfa and exhibits only one of several insect-host associations.

Abundance varies widely

The potato leafhopper is a native insect, a general feeder which infests many kinds of cultivated and wild plants, and a pest of many crops. The potato leafhopper readily accepted alfalfa and the clovers following their introduction and is now a major pest of these crops. It does not survive our winters, but migrates North each Summer. Its abundance in any given year varies greatly and damage may be serious or negligible.

The clover leaf weevil and the alfalfa weevil are introduced insects, brought to this country at different times from their native Eurasia. Both feed only on plants belonging to a single family. Their hosts, alfalfa and clovers, were also introduced from these same foreign areas. The clover leaf weevil, although both the adults and larvae feed upon alfalfa and clover foliage, is not ordinarily considered a pest. It is present each season, but rarely builds up to damaging levels and generally causes little injury.

The alfalfa weevil, in both the adult and larval states, also feeds upon alfalfa foliage. It differs greatly in its destructiveness, however, and can be most damaging to alfalfa. It is interesting to note that the alfalfa weevil, although a pest in its native home, has not been nearly as injurious there as in parts of the United States.

It is often observed that plants and animals which have been introduced into a new area quickly multiply and disperse, soon becoming more abundant than in their original habitat. The theoretical explanation for this lies in a comparison between the new and the old habitat. The new environment may be more favorable. There may be more ecological space available. The species may have escaped from its natural enemies. Whatever the governing factors, the phenomenon has frequently occurred, often with devastating results.

Insecticides help to safeguard our food supply, although they are needed to control only a few of the thousands of kinds of insects in Connecticut. Research helps to time sprays.

Following the appearance of a major pest insect in a new area, it is necessary to establish a multiplicity of facts. The investigator's immediate interest is not unlike that of the captain of a vessel following a collision at sea. He must first determine the nature and extent of the injury, then execute a program to repair or reduce the effects of the injury and prevent further loss. Later, the researcher assumes the role of the board of inquiry in accumulating detailed information leading to a thorough understanding of the situation from which a plan to prevent or minimize future injury may be developed.

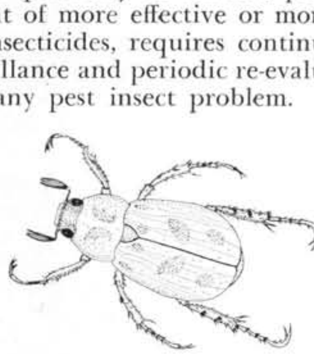
If possible, it is desirable to remove the threat completely. With insect pests, this means eradication. This does not seem possible with the alfalfa weevil for, although the insect is new to Connecticut, it has been in the West since 1904 and has been spreading in the East since 1951. It is now well established in broad areas, recognized as an integral part of the natural community, and our efforts are directed toward reducing and minimizing the effects of its feeding.

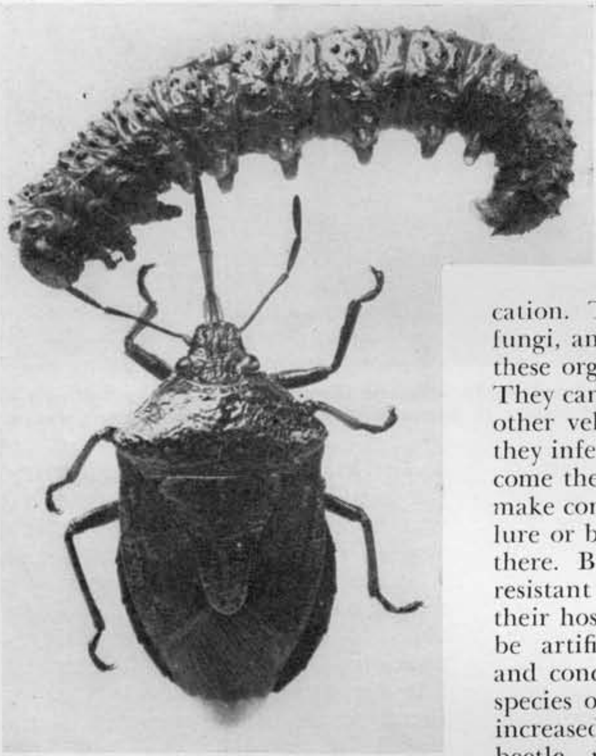
Anticipated arrival

Following positive identification of our first specimens, we surveyed the spread and relative density of the weevil population in Connecticut. The results showed the weevil to be generally distributed but, except in towns along our western border, numbers found were small. The historical data show that the weevil is apt to be a serious problem in the seasons immediately following its appearance in a new area. Thus, having appraised the status of the insect in the field, it was necessary to provide a defense against it. Considerable information was available from areas where the weevil has long been established and this provided a basis for our investigations. This work was started before the weevil was found in Connecticut. Aware of the presence of the weevil in the East, we had been watching the reports of its dispersal and awaited its almost inevitable appearance.

One phase of the control program which we could conduct in advance was the evaluation of insecticide residues on alfalfa. Based on their recorded performance against the weevil and closely related insects in other areas, the most promising materials were applied in the field and their residues determined by chemical analysis by Mr. Lloyd Keirstead of this Station. Information of this type is essential before a material can be approved for use, as a step in assuring that there are no harmful residues when treated forage is fed to dairy animals. Later, after the weevil arrived, the effectiveness of these materials in controlling both the adult and larval stages was evaluated. We are now studying methods and schedules for applying insecticides, and will soon turn to studies on the biology of the insect in Connecticut.

Once resolved, the problem cannot be considered closed, for the situation is not static. On the contrary, the recognized plasticity of insects, plus the advent of more effective or more specific insecticides, requires continuous surveillance and periodic re-evaluation of any pest insect problem.





This currant worm is being "controlled" biologically by a hungry predacious stinkbug.

Enemies of Insects Can Be Our Allies

by Raimon L. Beard . . . *Department of Entomology*

What is biological control?

Insects, like all animals, live if they can, die if they must. If they live, they must eat. If they are eaten, they die. This in simplest terms is the relationship between insect hosts or prey (the eaten) and the parasites or predators (the eaters). Insects may be host to many organisms. If they are host to pathogenic viruses, bacteria, fungi, or protozoa, we say they are diseased. If they contain within their bodies such flesh-eating animals as various worms or stages of other insects, we say they are parasitized. If they are eaten unceremoniously by other insects, spiders, toads, birds, bats, or moles, they are consumed by predators. Called by whatever name, the eaters kill the eaten. If they kill enough of an insect pest, they provide biological control.

What are the agents of biological control?

In spite of appearances, insects are not universally healthy. They can suffer congenital weaknesses and metabolic ailments. The wilt disease of the gypsy moth, discussed by Dr. Wallis, may actually be more like the latter than an infectious disease caused by virus.

Some viruses, however, spread from one individual insect to another—as does the Asian flu among humans. If an infectious virus is to kill large numbers of insects, it must be present among crowded hosts when conditions are favorable for virus multiplication. This is also true for bacteria, fungi, and possibly nematodes. All of these organisms are relatively passive. They can be spread by wind, water, or other vehicles, but for the most part they infect their hosts only if the hosts come their way and feed or otherwise make contact. These organisms do not lure or bait their hosts. They are just there. Because of life stages (spores) resistant to adverse conditions outside their hosts, these infective agents may be artificially spread among heavy and concentrated populations of pest species of insects. As a possibility for increased control of the Japanese beetle, milky disease bacteria have been spread widely. The use of fungi against the European corn borer and of viruses against the European spruce and pine sawflies, the alfalfa caterpillar, and the imported cabbageworm has also been widely publicized.

Most parasites and predators are able to seek out their hosts and prey. In contrast to predators, parasites tend to be specific and are able to live only on certain stages of certain insect species. They may even parasitize other specific parasites of a certain insect. The chain may be still more complicated, as inferred in the familiar ditty about little fleas having lesser fleas . . . *ad infinitum*. This, of course, makes host finding difficult. Such complex situations are of biologic interest and importance, but more often we are concerned with single parasite species that attack our major insect pests.

Among these are two species of *Tiphia* wasps that locate Japanese beetle grubs and deposit eggs upon them. The eggs hatch into larvae that feed upon and consume the grub. A tachinid fly parasitizes not the grub, but the adult beetle. The eggs of the European corn borer and the borers themselves are vulnerable to numerous other parasites. Before DDT came into common use, millions of *Macrocentrus* parasites were reared in our laboratory and released in the field to seek out and kill larvae of the Oriental fruit moth. These are but a few of the hosts and parasites that are of particular interest to us. Their special requirements mean that the parasites have small chance of surviving if they fail to locate their preferred hosts.

The less fastidious predators are more inclined to eat what they can find. This suggests that the most available food is their favorite—at least for the moment.

Predators have different habits and live in different places, so they do not all converge on one type of food. The most famous insect predator, the praying mantis, prowls the shrubbery where flies or grasshoppers may happen by. When it spots and captures a victim, it gives undivided attention to eating. It devours every morsel, and then preens itself before considering another victim. The ambush bug, *Phymata,* lies in wait among goldenrod flowers for flies and bees that are attracted there. If it is in the midst of feeding and another insect comes within range, it will reach out with a free leg, capture the victim and hold it in reserve while it finishes its first course. Other insects are still more gluttonous. I watched a ground beetle (*Calosoma*) feed without interruption for two hours and forty minutes. During this time it consumed fifteen larvae of *Archips* (the ugly nest cherry worm). This kind of voracious predation can really make inroads on an insect population.

Higher animals help

Predation by higher animals is familiar to everyone. Fish keep many a pond free of mosquitoes. Toads are well known friends of gardeners. Insectivorous birds enjoy a fine reputation, and the story of the gulls stopping the plague of Mormon crickets is told to school children everywhere. We have all seen woodpeckers digging borers from corn stalks; phoebes capturing flies on the wing; starlings digging in the turf for grubs. Moles (and shrews, too) kill a great many grubs in the soil. Often we don't appreciate their efforts in our lawns, believing them to be as troublesome as the grubs they eat.

Natural baiting and trapping of insects for food is not common. Spiders, of course, set very effective traps for unwary insects. Even a chemical bait is not unknown. A predaceous bug in Sumatra secretes a fluid that is attractive to ants. When the ant comes to feed, it becomes food for the bug.

The use of chemicals in killing insects is generally thought to be a human invention, and is often spoken of as artificial control. This is not so. The first chemical insecticides came into use millions of years ago when predaceous wasps began stinging their prey and predaceous bugs and spiders began biting their victims, killing them with poisonous saliva. Some of these venoms and poisons are amazingly potent, and in their own peculiar way are more effective than any insecticide we commonly use. All these parasites and predators use the means at their disposal for securing food. Viewed in this light, some of our own control practices may be unwise, but they are not unnatural.

Is biological control effective?

How good must biological control be to be effective? Effective control is relative. Control implies regulation, but what we really mean is the reduction in numbers of the kinds of insects we don't want. Large numbers of fireflies or monarch butterflies don't worry us. In fact, we like to have them around. Not so the apple maggot. We don't like to eat the worm in the apple, and eating around it is wasteful; so we seek, even if we don't achieve, complete control. In this instance our primary concern is in protecting quality, although in doing this we also increase yield. In other cases we may be concerned only with the total harvest of a crop or possibly the reduction of an insect nuisance.

With any given population level of an insect it must be remembered that, in general all the offspring of a pair of insects, save two, must die if the population is to remain the same. If this population is a tolerable one, we may be satisfied with this mortality. But if more than two survive for every original pair, the insect increases in numbers. Most insects, especially pest species, have remarkable powers of increase. They are notoriously fertile. One statistic, often quoted, is that if all the progeny of one pair of houseflies survived and reproduced normally in one season, 191,000,000,000,000,000,000 flies would result. Fortunately this does not happen. Many natural control factors are operating. Sometimes one, sometimes another factor seems most important, but they all add up to kill, each season, the *potential* 190,999,999,999,999,999,998 flies for each original pair.

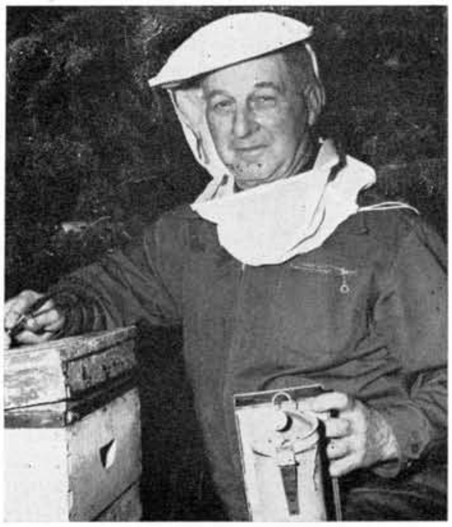
A more general question is important in biological control and should be raised even if it cannot be answered categorically. Are there factors that begin to operate more severely when an insect population begins to increase? In other words, is there a "feedback" mechanism whereby an outbreak of insects is automatically brought under control simply because there is greater mortality caused by something that acts more effectively when insects are more numerous? A frigid winter, or a flood, is likely to kill about the same proportion of insects whether there are few or many. On the other hand, under crowded conditions, pest insects may get less to eat, so may lay fewer eggs and otherwise compete with each other to cause a reduction to more normal levels. Also under crowded conditions the infectious disease organisms have a greater chance of developing. When parasites have less trouble finding their hosts, and predators have an abundance of food, they, too, begin to multiply. We have all seen this happen. In 1956, when conditions were so favorable for aphids, their predators, the lady beetles, also became very abundant—so abundant, in fact, that when they went into hibernation in the fall, they themselves were a nuisance to many householders.

If this sort of "governor" operates to control populations, how is it possible for insects to increase so as to get out of hand and require special control? For one thing, the increase in these natural controls always is slower than the increase of the pest. This lag is only one of many elements in a complex set of circumstances—and few situations are just alike among insect populations. Let us look at two situations that we have observed closely.

Susceptibility varies

The story of milky disease of Japanese beetle grubs is convincing, and one might wonder why it has not resulted in the complete extermination of this insect. Spores of this bacterium are very resistant and can remain in the soil, in good condition, for long periods. If a grub takes in with its food sufficient spores, the spores become active and the bacteria multiply to tremendous numbers in the blood of the host. In time, the bacteria change to the spore form; the grub dies and breaks down in the soil, releasing billions of new bacterial spores. As more grubs get infected, more billions of spores are added to the soil. It shouldn't take long for the soil to be so filled with bacteria that a grub couldn't survive. Does this happen? Certainly it does in the laboratory, and possibly sometimes locally in the field, but not always. Why? Last winter Asian flu became epidemic. Although it is highly infectious, everyone did not get it because people vary in their susceptibility, and everyone was not equally exposed. The same principles apply to insects. A very heavy dose of spores is required to cause infection in the grub. Grubs, too, vary in susceptibility; not all the grubs get enough spores to develop an infection. The disease is rather slow in killing the grubs, so contribution of new spores to the soil is slow. And even if billions of spores are added for every dead grub, there is a lot of soil—even in a small lawn—and some grubs escape. The disease has contributed to the general decline of the Japanese beetle, but some grubs will continue to avoid infection, and at times the insect will increase in spite of the bacteria in the soil.

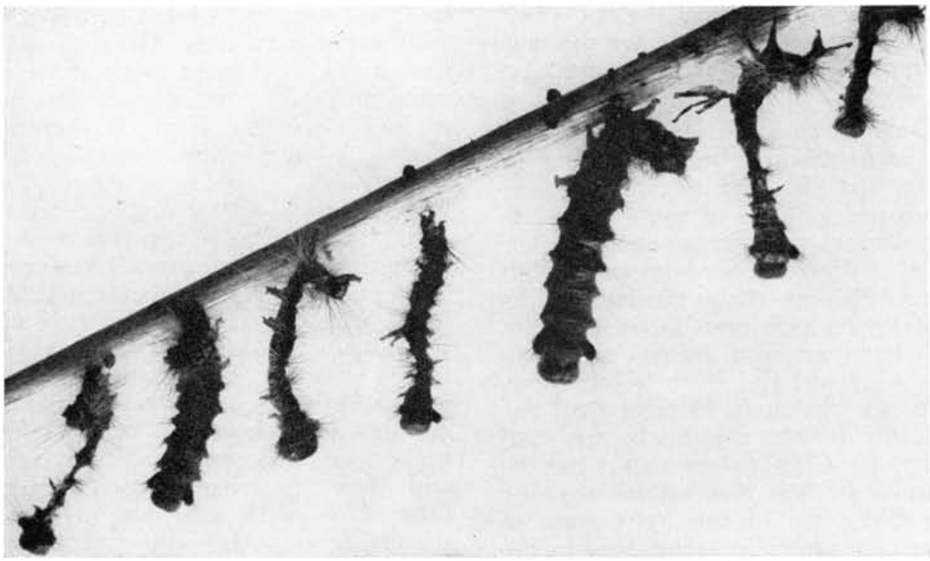
Our common squash bug parasitized by a tachinid fly provides another example. The female parasite searches at random among the squash plants for host bugs, depositing eggs upon those she finds. She is, in one sense, inefficient. Some bugs are overlooked; some are found again and again. As only one parasite can develop in each host, many eggs are thus wasted. The bug has one generation each year, the fly has three. The fly would appear to have a much greater advantage and would keep the bug at very low population levels. Actually the life cycles are not synchronized so as to permit this, and large numbers of both bugs and parasites are possible. From the parasite's point of view this is fine; it always has an abundance of hosts to keep it going. From the bug's point of view,



Disease strikes both insect friends and enemies. Inspection of apiaries has been the job of Roy Stadel, who retired in February after nearly 18 years of service to Connecticut beekeepers.

this isn't too bad; some must be sacrificed to parasites to be sure, but many escape. From our point of view alone, it is not good; we prefer bug-free squash.

Biological control has great appeal because it introduces no hazard to us, and where effective, can relieve us of much work. It is difficult to evaluate, but we know that sometimes its effect is great, sometimes small. Sometimes we can aid and augment its effectiveness. At other times we unwittingly block its action. At still other times we must choose between partial biological control and our own devices that sacrifice that control. To be wise in our choices, we must understand the complex interrelationship of biological forces. To understand these, we must study, observe, and experiment. This we are doing.



"Wilted" caterpillars hang from a stick, in laboratory study of polyhedrosis disease. They died of the disease after a diet of wet food for a period of 3 days, in a humid atmosphere.

Ecology and Caterpillars

by Robert C. Wallis . . . *Department of Entomology*

Ernst Heinrich Haeckel, the great biologist and philosopher, defined the word "oecology" in 1870. He spoke of oecology as the outer physiology of organisms. The Americanized word, ecology, has come to mean the scientific study of plants and animals in relation to their environment. Insect ecology, therefore, cannot be overlooked by the entomologist. Our present knowledge of the gypsy moth in Connecticut gives evidence that research in ecology helps us devise methods of insect control.

The gypsy moth is profoundly influenced by its environment. In 1896, E. H. Forbush and C. H. Fernald, in Massachusetts, found that young gypsy moth caterpillars tended to migrate toward strong sources of light.

In 1930, deLapiney, a French scientist working in North Africa, discovered that the caterpillars moved upward. He also found they were strongly attracted to tall poles and trees. He described a leaf-feeding period and a resting period, after which strong sunlight stimulated the caterpillars to migrate.

Only seven years ago, a practical relationship between caterpillar migration and differences in tree damage was suggested by H. A. Bess, S. H. Spurr, and E. W. Littlefield, American entomologists. They reported that caterpillars sometimes crawled down from the woodland canopy into the litter and understory where many were eaten by small mammals. Under other conditions the caterpillars stayed up in the tree tops, eating leaves. Bess and his coworkers suggested that the caterpillars migrated downward to seek cool moist places, to rest and complete their development to the pupal stage.

In our current laboratory study of gypsy moth ecology, we set out to study this hypothesis. Using gypsy moth larvae reared under test conditions, we confirmed the earlier findings: the young caterpillars were attracted toward strong light, they tended to crawl upward, and they were stimulated from the resting stage by strong light. We saw no preference, however, for cool moist places. But as the caterpillars grew they no longer moved toward a source of light. Within a few weeks the pronounced reaction of young caterpillars was completely lost. This, we believe helps account for the "crawl down" from the tree tops. The lure of light is outgrown, but the cool moist retreat holds no charm.

Disease also has important effects on the caterpillar population. The virus "wilt" disease, or polyhedrosis, has long been studied by entomologists as a means of natural control. But the laboratory findings have been controversial, and field trials have been disappointing. Entomologists put "the cart before the horse." Attempts to use the virus disease against the gypsy moth came before the disease itself was fully understood.

In our laboratory we have turned to study of the ecology (or epidemiology) of the wilt disease itself. We want to know the conditions under which it really becomes epidemic. We have found, for example, that the virus is widely dispersed among caterpillars, even in areas free from vast epidemics. On the other hand, outbreaks of disease may occur in highly infested areas.

Environment is critical in activation of the disease. We find very little wilt disease when the relative humidity is low—as during the 1956 caterpillar feeding season. In the laboratory, larvae kept in a dry atmosphere are vigorous and healthy. They eat an enormous amount of foliage and are not susceptible to the virus disease. Under warm moist conditions, however, they get sluggish, feed less, and rapidly die off from the virus wilt. This seems to be important in limiting the population of the gypsy moth in southern Connecticut and is a logical explanation of unpredicted build-ups of the population in certain dry years and not in others.

Understanding the conditions favorable for unusually high caterpillar vigor and feeding activity (low relative humidity during the larval feeding season in the spring) and those which lead to low feeding activity and high susceptibility to wilt disease (warm, damp spring seasons), helps to explain and to predict the defoliation pattern. In certain large areas of Harwinton, and in the southern and eastern portions of the state where the humidity is high, we now know that defoliation will not occur even in highly infested susceptible woodland – except in unusually dry spring seasons.

Strange as it may seem to experiment with viruses in caterpillars and factors which stimulate their activity, our studies of insect ecology pay off.

Where Do We Stand On Gypsy Moth Control?

by Neely Turner . . . *State Entomologist*

The gypsy moth of Connecticut woodlands is a native of the old world, and was first established in this country in Massachusetts about 1869, It multiplied rapidly and became a serious nuisance in built-up areas. Efforts to suppress the pest were so successful that they were stopped. The gypsy moth promptly increased and spread into Connecticut in 1905. Its spread has never been stopped since that time. The insect now occurs in about 40 million acres of woodland in New England, New York, and Pennsylvania: eradication of infestations in New Jersey and Michigan is claimed.

The detailed life history of this insect is given in Station Circular 186, available on request. Eggs over-winter in masses on the bark of trees, stones, posts, and buildings. The larvae hatch about May 1 and feed on the leaves of oak, white and gray birch, willow, linden, apple, and many other hardwoods. Pupation is in July and the moths emerge about August 1. The females cannot fly; they mate and lay eggs near the place where they emerge.

When the pest was found in Connecticut, rigid quarantine was established to prevent transfer of eggs, and the small original infestations were eliminated. Additional infestations were found in 1914 and by 1922 every county except Fairfield had several. From 1906 to 1921 the principal effort was to eradicate the pest. From 1922 to 1939 the work was directed at preventing further spread, with the idea that extermination would follow.

The first serious outbreak of the gypsy moth occurred in Granby and Simsbury in 1938-39. All of the control work was concentrated in those two towns and even so did not prevent defoliation of almost 2,900 acres of woodland.

Dr. R. B. Friend, then State Entomologist, started a thorough study of the insect, which he completed and published in 1945.* He concluded that the gypsy moth had attained the status of a native insect pest, with natural controls operating in such a way that only sporadic local outbreaks would occur in forests. This conclusion was supported by the status of the infestation east of the Connecticut River. Spraying was last done there in 1939, and when his report was written 1945, no serious infestation had developed.

A new system of gypsy moth control was developed. Obviously, the pest could not prosper in woodlands lacking host trees. The type of woodland growth was mapped, and scouting done only in areas favorable to the pest. Permanent study plots were established so that changing populations could be estimated with a minimum of scouting. The relation between number of egg masses and degree of defoliation was established. Finally, the decision was made to spray only those woodlands in danger of serious defoliation.

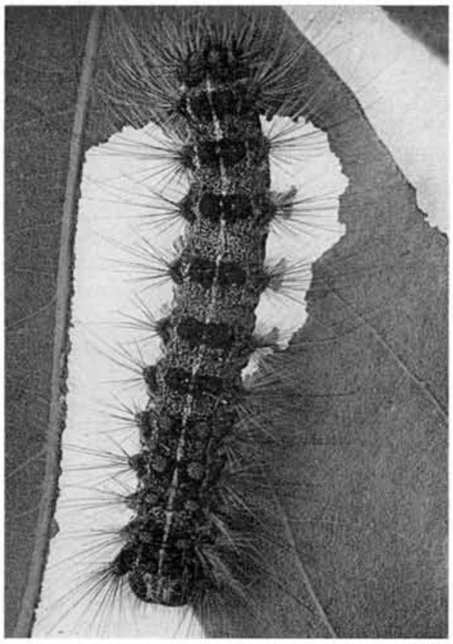
The system works

This system has been tested by time, and has been remarkably effective. Outbreaks have been forecast from the study plots. Reasonably accurate estimates have been made of the areas in danger of defoliation. These estimates have been made in ample time to arrange for spraying. The General Assembly has passed a new statute on gypsy moth. The State Entomologist is to scout the woodlands, determine the areas in danger of serious defoliation, notify the towns and assist them in arranging for spraying if they so elect, and partially reimburse those towns that spray. He is also authorized to spray public woodlands, using public funds.

Because the gypsy moth was not native here, and because the females cannot fly, a quarantine offered promise of restricting its spread. Beginning in 1906, articles capable of transporting egg masses have moved from the quarantined area only after inspection.

Unfortunately, there are other means of spread. The light, newly hatched caterpillars can be carried long distances by the wind. Wind spread was undoubtedly responsible for infestations in 1914, 1915, and 1921. Wind spread obviously makes a quarantine only partly effective.

The development of airplane spraying and of DDT provided for excellent control of the gypsy moth at relatively low cost. Large areas can be treated at a cost of a little more than one dollar an acre. At the outset people interested in wildlife had some misgivings as to the effect of these sprays. In Connecticut, tests were made in various types of woodland, with careful study of the effect on birds, fish, amphibians, reptiles, and mammals. Experts found little permanent effect on wildlife when woodlands were sprayed for control of the gypsy moth.



Dry leaves and dry air keep this growing gypsy moth larva vigorous, healthy, and destructive.

Nevertheless, the General Assembly passed a statute regulating the application of chemicals by aircraft. The need for such legislation was demonstrated the first year after its passage. Careless application of mosquito sprays damaged tobacco seriously, and drifting dusts annoyed residents of rural areas. Occasionally careless applications killed fish in shallow ponds. The noise of planes was a nuisance to residents. The present regulations were written to minimize such annoyances. Furthermore, the Fish and Game Department has veto power to prevent spraying that is injurious to wildlife.

All of the airplane spraying done in Connecticut for control of the gypsy moth has been done under this statute. Spraying of several hundred thousand acres of woodland under these restrictions has clearly not been catastrophic to wildlife, but experience has shown that there are some risks. The most serious is the relation between area treated and hazard to fish. Spraying even 1,000 acres usually has little permanent effect on fish or the insects eaten by fish. When large

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*The publication of this study has been reprinted and is available for distribution on request.

The Place of Insecticides

The use of insecticides is to an economic entomologist the last step, to be taken only after all other methods of control have been found wanting. The classical approach to insect control has always been, first, to study the life history of the pest, with the hope of finding some way to avoid its damage. If that is unsuccessful, the second approach is to study the parasites, predators, and diseases of the insect. If these offer no relief, the use of insecticides to prevent serious economic losses is considered as a third resort . . . .

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areas are treated, and sudden heavy rains occur immediately, DDT can be washed into streams and lakes from large watersheds and kill the insect food of fish. The population of fish may then be seriously reduced. In large operations there is also more hazard of "accidents," such as repeated sprayings of small areas where planes turn, sudden shifts of wind to spray over areas supposed to be avoided, or spraying areas not included in the schedule when large areas and many pilots are involved.

The states uninfested by the gypsy moth, particularly those adjoining the infested area, naturally do not want this pest. The development of airplane spraying with DDT has stimulated a concerted demand for the infested states to attempt eradication. The first spraying on such a basis was done in states adjoining the generally infested area in 1957.

The gypsy moth statute (Sec. 1776d, 1955 Supplement to the General Statutes) calls for control and not for eradication. New legislation will be required if eradication is to be tried. Research of Station entomologists, and the experience with the pest in the past may be summarized as follows:

(1) Thus far the gypsy moth has caused serious defoliation in Hartford County west of the Connecticut River, in Litchfield County, and in the northern part of New Haven County. The area east of the Connecticut River has not been sprayed since 1939, and no serious defoliation has occurred.

(2) The maximum area heavily damaged in the year of worst infestation was about 200,000 acres in 1954. This is about 10 per cent of the total woodland in Connecticut.

(3) The economic losses from gypsy moth have been relatively low and were estimated at $25,114 on 19,081 acres in the period up to 1952. If these figures are dependable, the cost of spraying just about equals the potential damage. The nuisance of caterpillars crawling over houses and gardens is very great in heavily infested suburban areas.

(4) More than $90,000,000 have been spent by towns, states, and the Federal government in gypsy moth quarantine, control, and eradication. Expenditures in Connecticut for quarantine and eradication total about $750,000 and, for control, another $750,000 in 52 years. More Connecticut public funds have been spent on the gypsy moth than on all other imported pests combined.

(5) The total cost of spraying in Connecticut to prevent defoliation averaged about $55,000 a year between 1951 and 1958 during the most recent outbreak. If the nine years before the outbreak are included, the average annual cost was $27,500.

(6) The cost of eradication spraying in Connecticut would be at least $2,000,000, plus the cost of follow-up sprays to eliminate gypsy moths missed the first time.

(7) Evidence on the possibility of eradicating the gypsy moth from 40 million acres by spraying with DDT is scanty. In general research entomologists feel that the probability of success is not very high.

(8) The hazard of eradication spraying with DDT to birds and land animals other than insects is not great. The hazard to fish seems greater.

(9) Contamination of pastures and forage crops with DDT is inevitable when trees adjoining farm land are sprayed by aircraft.

(10) Natural controls, including parasites and predators introduced by the U.S.D.A., have prevented outbreaks in the eastern half of the state. Intensive study of natural control is under way to determine whether or not these factors can also operate in the northwestern part of the state.

(11) Some of the worst infestations have occurred in woodlands of little commercial value. Improvement of these woodlands by encouraging the original species of trees there would reduce the hazard of serious damage by the gypsy moth.

New Publications

The publications listed below are now available to those who apply for single copies to Publications, The Connecticut Agricultural Experiment Station, Box 1106, New Haven 4, Connecticut.

Reports on Inspections

B 607 Commercial Fertilizers, 1957
B 609 Food and Drugs, 1955

Soils

B 608 Root Growth in Connecticut Tobacco Soils

Tobacco

B 612 Influence of Wet-Bulb Temperature During Curing on Properties of Shade-Grown Tobacco

A Date to Remember

Annual Field Day of the Station Experimental Farm, Mt. Carmel
Saturday, August 16, 1958

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