United States
Environmental Protection
Agency

Office of
Pesticide Programs
Integrated Pest Management Unit

December 1979
Washington DC 20460

Pesticides

EPA

Common Sense Pest Control for the Home and Garden

December 1979

COMMON SENSE PEST CONTROL FOR THE HOME AND GARDEN

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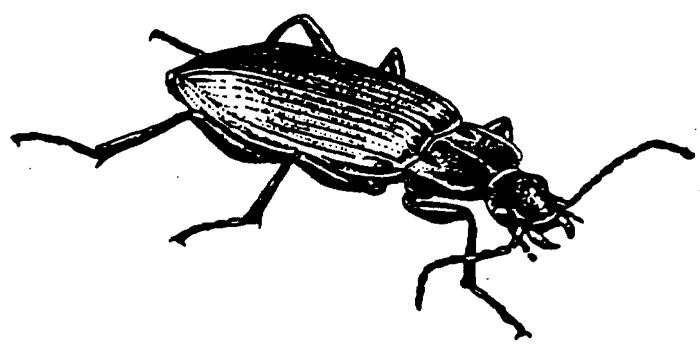

Produced under contract for the Environmental
Protection Agency, Local Region IX by:
Center for the Integration of the Applied Sciences
a division of the John Muir Institute

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CIAS has worked for several years under the direction of William and Helga Olkowski to develop effective integrated shade tree pest management programs for a number of California cities. Current CIAS work also includes an IPM for flood control levees for the California Department of Water Resources; development of urban IPM implementation plans for the California Department of Food and Agriculture; several parasite importation and distribution projects; the development of an IPM program for the National Capitol Region of the National Park Service (Washington, D.C.); and an EPA contract to establish a computerized data base for urban insect pests (including their predators, parasites, habitat, etc.) in the continental United States. In addition, through a cooperative agreement with EPA, CIAS is developing a pilot technical assistance center in urban IPM and alternatives to pesticide use for communities across the nation. A list of the Center's publications may be obtained by writing to CIAS, 1307 Acton St., Berkeley, CA 94706, or phoning (415) 524-8404.

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Common Sense Pest Control was prepared with the assistance of:
Diane Kuhn, Lisa Haderlie, drawings
Frederica Bowcutt, Gina Rosenberg, layout and design

Produced under contract (68-10-4475)
for the Environmental Protection Agency

Contract Management
Region IX
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The cover drawing is of the common ground beetle in the San Francisco Bay area, Pterostichus sp., which feeds on caterpillars, worms, and a variety of soil organisms.

COMMON SENSE PEST CONTROL FOR THE HOME AND GARDEN

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COMMON SENSE PEST CONTROL FOR THE HOME AND GARDEN

Is it possible to reduce damage and annoyance from insects and other pests without relying exclusively on poisons? Yes, it is, but to do so successfully you need some information and some patience. This pamphlet can help you with the first, if you are willing to supply the latter.

Specific pest problems used here to illustrate pest management approaches are drawn from the Central California coastal and valley urban areas. However, the general strategies suggested should be useful anywhere.

I. What Controls Insects "Naturally"?

Many insect populations are capable of expanding very rapidly. For example: the common housefly (Figure 1) can lay one thousand eggs in a season. If one hundred flies occupy one cubic inch, then in a single summer one pair of flies might produce enough offspring to cover the planet with a layer of insects four thousand feet thick. This has never happened because insects, like all animal populations, are under natural control. The most important of these are climate and weather, habitat and food, disease, and predators and parasites.

Climate is the long-term overview of temperature and humidity changes in a region. Weather is its local and short-term variation. Extremes of heat and cold, of rainfall, dew and fog, can limit an insect population as well as influence its seasonal distribution. For example, whether the tomato hornworm (Figure 2) is a pest in your area may be due to whether your climate is favorable (valley) or not (coastal). But whether the outbreak is early or late in the season, and to some extent how large it is, may be a function of the weather that particular year.

With many insects, warm weather increases the speed with which they mature from larvae (the young form) to adult, while cool weather will retard it. Thus weather can influence how quickly a population can build up. Green bottle flies are a good example (Figure 3). With ample food the flies can go from egg to adult and be ready to mate and lay new eggs in as little as six days when the temperatures are over 95° F (35× C). Thus a generation can easily mature in the garbage can between refuse collections, without the householder being aware of it, particularly if only once per week garbage collection occurs.

Habitat and food may be important limiting factors upon a pest population. For example, in some areas the ash aphid, Prociphilus fraxinifolii, common on Modesto ash trees, may prefer to live in the sucker growth around the base of the tree as well as within the inner canopy. When these suckers are pruned away, the remaining population of aphids in the tree may be so small as to be rarely noticed. On the other hand, if the main outer branches are severely pruned in such a way as to encourage sucker growth, the ash tree may appear to have suddenly developed an aphid problem as these insects multiply in their favored habitat.

The actual nutrient balance within the plant may affect the insects also. Deciduous tree insects, such as the aphid we have just described, may go through

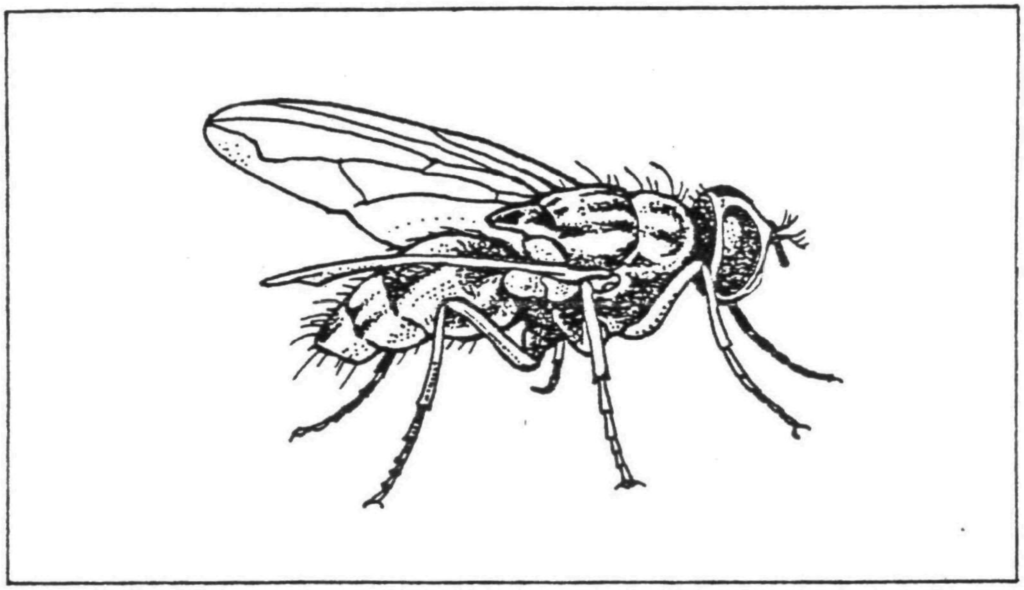


Figure 1. The common housefly, Musca domestica develops in decomposing organic matter such as garbage and pet feces.

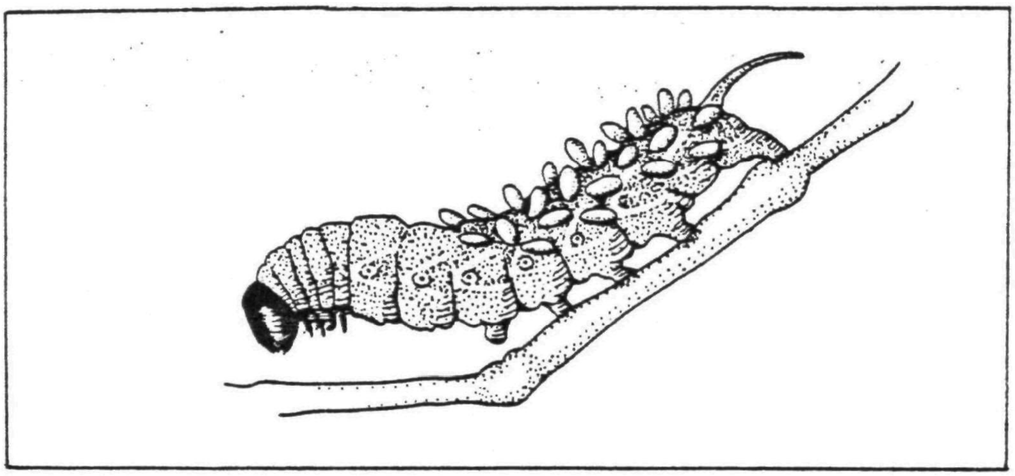


Figure 2. Manduca (Protoparce) quinquemaculata, the tomato hornworm and its close relative M. sexta, the tobacco hornworm frequently occur in the same gardens throughout North America. The hornworm likes warm summers and is rarely found where the weather remains cool as along the northern California coast. Both species of hornworms are often found with attached larvae or cocoons of the parasitic mini-wasp, Apanteles congregatus, a natural enemy of these caterpillars.

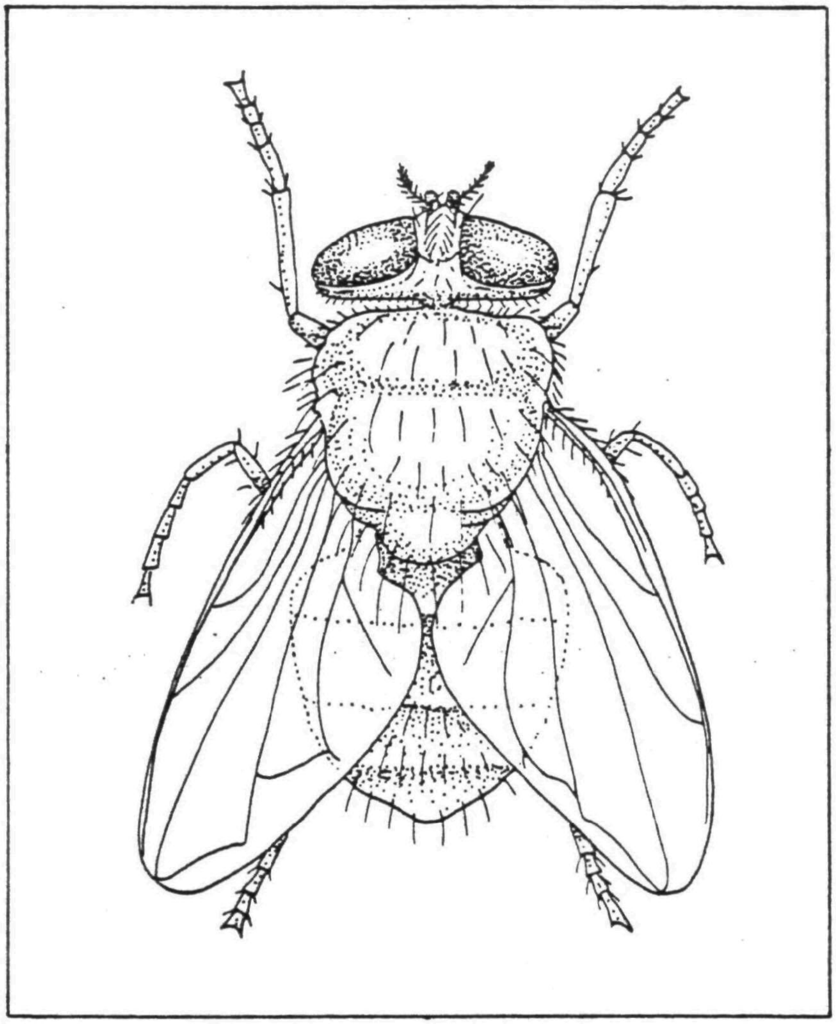


Figure 3. The green bottle fly, Phaenicia sericata, develops in garbage as a larva and also feeds on materials like dog manure as an adult.

two population peaks each season responding to the two times when nitrogen is highest in the foliage - in the spring, when the leaves first unfold, and in the fall, when they are ready to drop. Aphids may be unintentionally encouraged through over-use of nitrogen fertilizers in the home garden as well. Nitrogen is used by the aphid to form new tissues and also in producing young. Thus the high nitrogen nutrient levels mean higher aphid populations.

Another local common pest, the brown garden snail, Helix aspersa (see Figure 4), may also be encouraged by increasing its favored habitats such as beds of ivy and succulents that provide a humid cover. It likes to lay its eggs under boards lying on the soil. If these are used to provide dry passageway over muddy areas, dry sawdust should be placed beneath them to discourage snail (and slug) breeding there.

Disease is common to all animals and, just as with humans, crowding of large populations may encourage the rapid spread of pathogens (disease-causing organisms). Some bacteria and viruses may cause diseases in insects, and a few have been produced commercially and registered for use. A number of insect diseases are caused by fungi. Raising the humidity of the immediate environment may help their spread. Mulches at the base of elm trees, for example, may encourage mortality by fungus disease among the elm leaf beetles when the larvae come down to the base of the tree to pupate (as when a butterfly forms a cocoon). Water washing to remove sticky honeydew secreted by large aphid populations may also encourage outbreaks of fungal diseases because such disease-causing organisms are favored by high moisture levels.

Predators and parasites, the natural enemies of plant-feeding insects, are very important in controlling pests. If you want to be able to manage such garden problems without using pesticides you should learn to recognize some of the common beneficial insects in your area.

Predators are usually larger than their prey and tend to eat many of them. Ladybird beetles, ladybugs (such as Hippodamia convergens) are the best known of these (see Figure 5). Many people do not realize that there are almost 150 species in the San Francisco Bay area alone and four hundred in the nation as a whole. Some are very particular about what they eat. For example, a commercially available lady beetle, the mealybug destroyer, is a specific predator of injurious mealybugs.

The convergent ladybeetle (Figure 5) is widely available commercially and often bought by home gardeners for aphid control. This is the beetle that flies to the foothills of the Sierras and other streamside hibernating sites where it congregates in large numbers and is easily scooped up by the millions. Unfortunately, many people do not know that ladybugs so gathered, without subsequent treatments, will fly to burn off stored fat deposits. Thus, when released, the beetles fly to another area. Frequently, just at the time of purchase and release of the hibernating beetles, the migrating ones are flying into yards and are mistaken for those released. If you decide to purchase ladybeetles, be sure that they are described as defatted.

Other important predators are green and brown lacewings, hover flies, rove and ground beetles and various predatory "bugs" (Figure 6). The important thing about

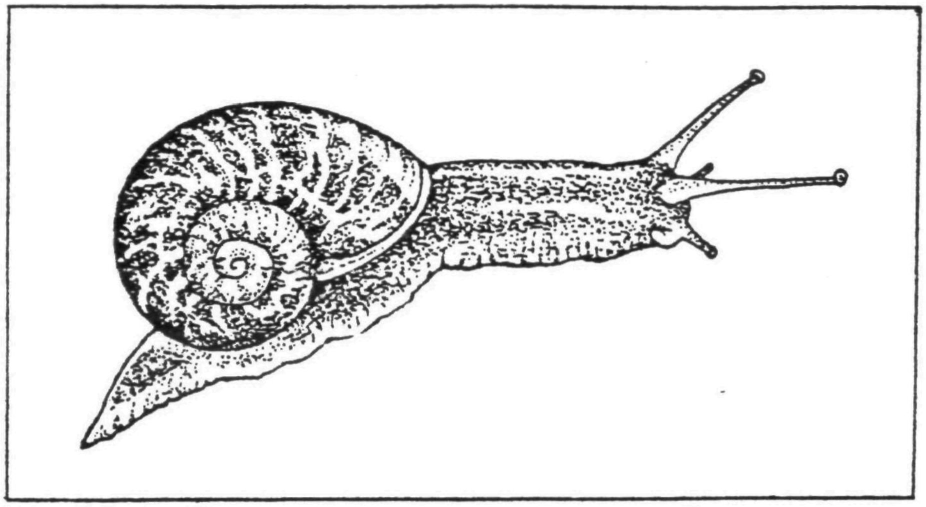


Figure 4. The brown garden snail, Helix aspersa was introduced into California in the 1850's as a food source. Today it is widely poisoned as a U.S. pest while at the same time, cooked and sauced, it is being imported from Europe as a gourmet delicacy.

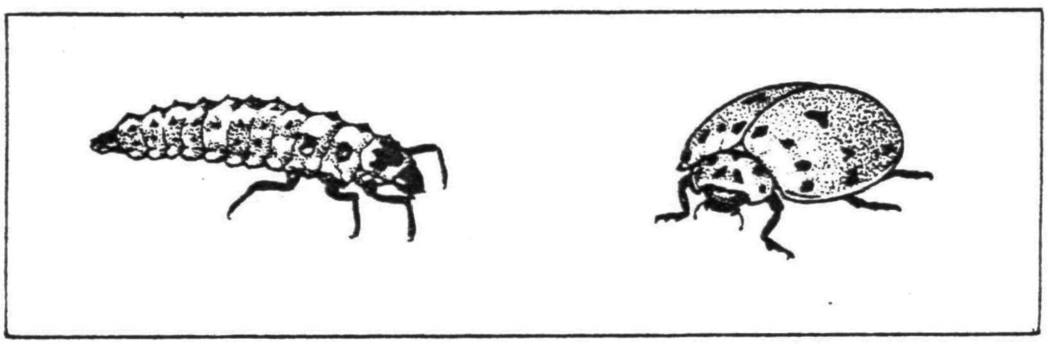


Figure 5. The larva and adult of the convergent ladybeetle, Hippodamia convergens, which occurs throughout North America. The twelve black spots are not always distinct or present.

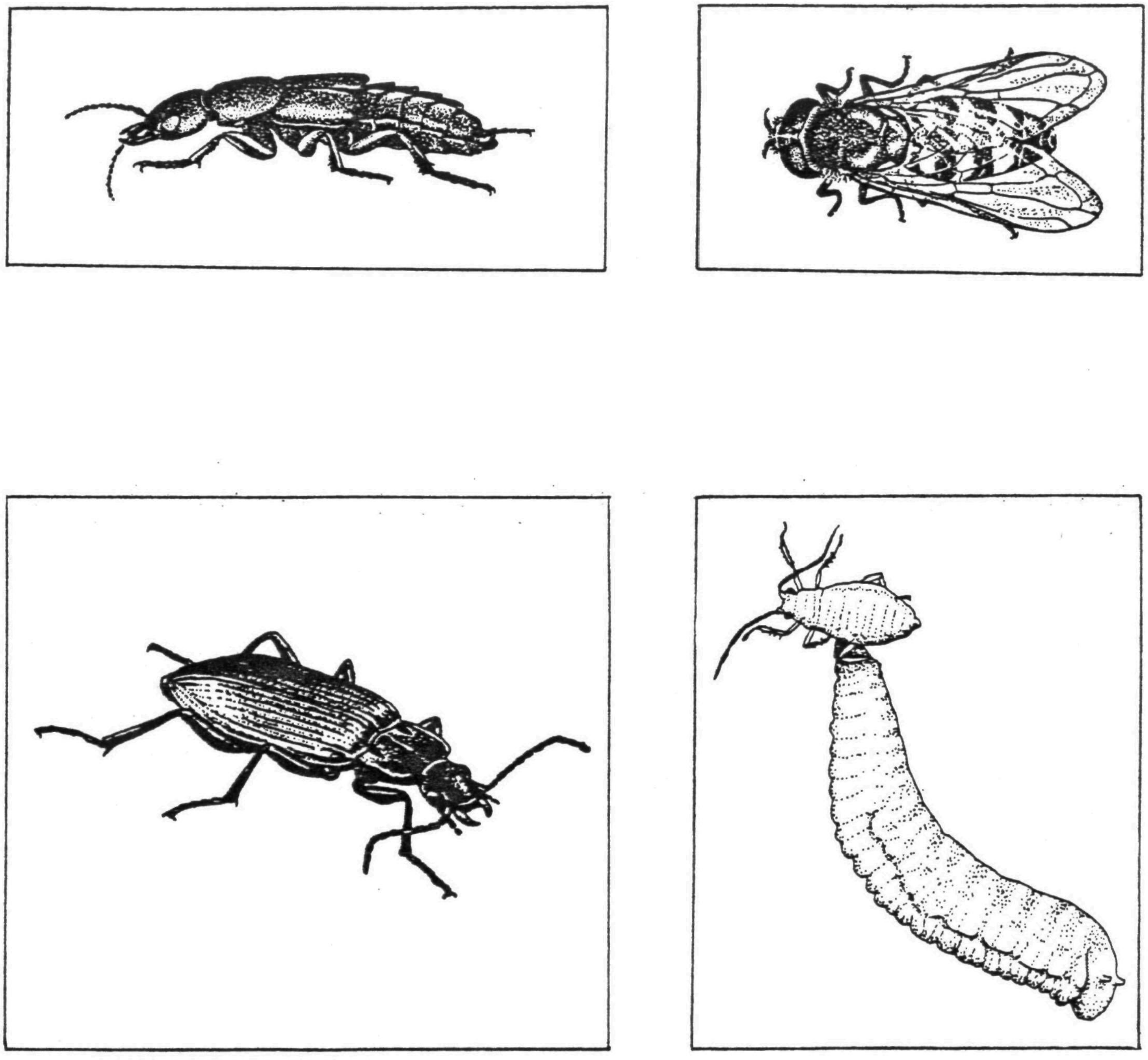


Figure 6. Some common beneficial insects of the home garden: top left, rove beetle; bottom left, ground beetle; top right, adult flower fly (also called hover fly and syrphid fly); bottom right, flower fly larva attacking an aphid.

these insect predators is that if they are not naturally restricted in their diet to feeding on a specific species of pest, they will tend to be opportunists, moving from species to species, feeding on whatever is most abundant at the moment. Thus, although they are helpful in reducing pest population sizes, they may not reduce the numbers of pests to an acceptable level unless sufficient numbers are present. One way to accomplish this is to intentionally release them for that purpose. Some insectaries are producing such insects and many species are now commercially available.

Parasites, on the other hand, are usually smaller than their prey. The parasitic natural enemies of insects are sometimes called parasitoids because, although their way of life resembles that of true parasites, unlike the latter they kill their host. They may consume only one individual during their lifetime. Many are members of the order Hymenoptera, along with the bees and wasps. Often they look like minute wasps or "mini-wasps". Parasites can offer good control of an insect population, even when the latter is present at very low densities because they are restricted in the number of species they can attack. Although these mini-wasps are very common, they are very small and most people are unaware of them; consequently, they usually don't have common names.

A common life cycle starts with an adult female mini-wasp laying her egg inside of or on a specific stage of another insect. For example, the elm leaf beetle has one parasite that lays its eggs in the eggs of the beetle (see Figure 7), and another one that lays its eggs in the pupa (cocoon stage). These parasitoids do not attack other insect species. An aphid parasite may feed upon and thus kill several aphids during the process of selecting one in which to lay its egg. These parasites may operate like predators and wound their host with their egg-laying stinger (or ovipositor) without depositing an egg (see Figure 8). They then feed on this wound, killing their host. Some parasites lay many eggs within or on the body of their hosts; others lay only one. In any case, the egg develops into a maggot-like larva which begins to eat away its host, sooner or later causing its death. After killing its host, the larva of the mini-wasp changes into a pupa. Aphid parasites may do this within the aphid itself. These dead parasitized aphids can be easily spotted in a colony of living ones. They are usually a slightly different color, stiff and shiny. Other parasites may leave the dead host to spin a cocoon somewhere nearby (see Figure 9).

Within the pupal case, the insect changes (metamorphoses) from maggot-like to wasp-like adult form. With some species of parasites the newly emerged female adults must find males to mate with before they can lay fertile eggs to start the cycle over again. With others mating is unnecessary, and males are unknown or rarely found.

Through understanding something about the many natural controls of insect and other animal populations, new possibilities for managing pests may become apparent.

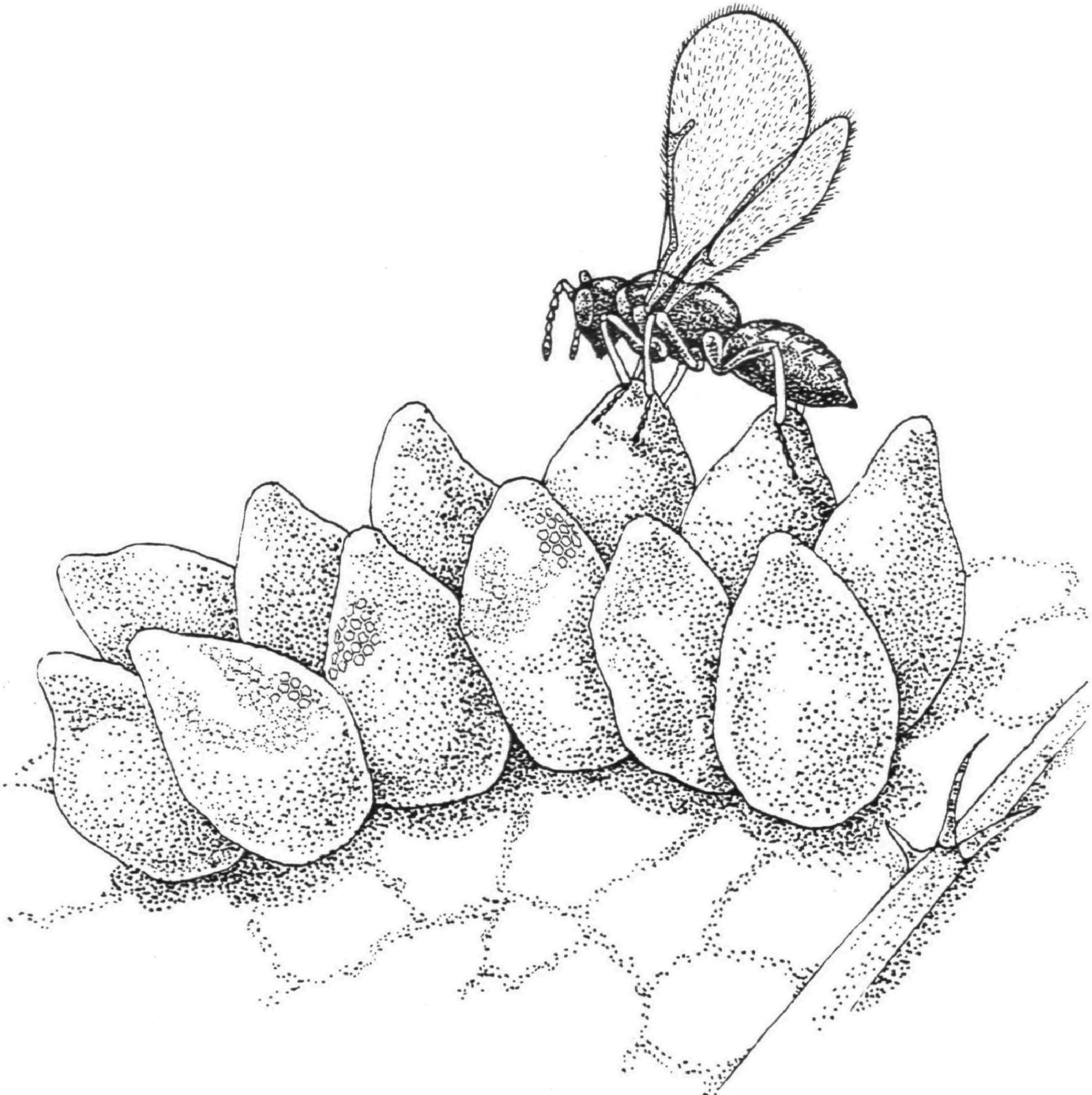


Figure 7. The eulophid egg parasite, Tetrastichus galerucae, only attacks the early stages of the eggs of the elm leaf beetle.

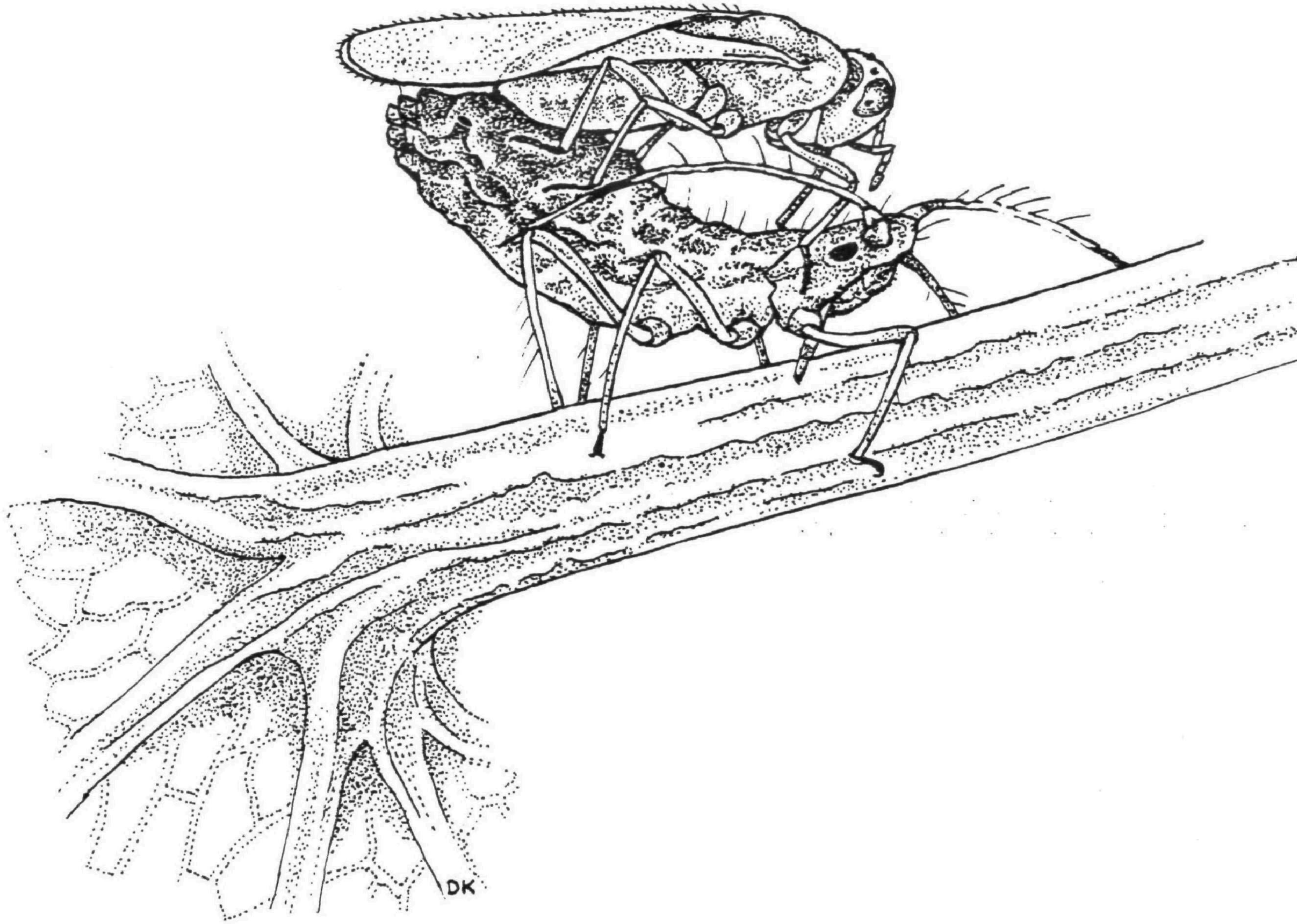


Figure 8. The aphelinid, Mesidiopsis sp., operates as a parasite or a predator on a number of tree aphid species. As a parasite it lays its egg within the aphid. The egg develops into a larva which eats the aphid from the inside. As a predator, Mesidiopsis punctures the live aphids and sucks out their juices.

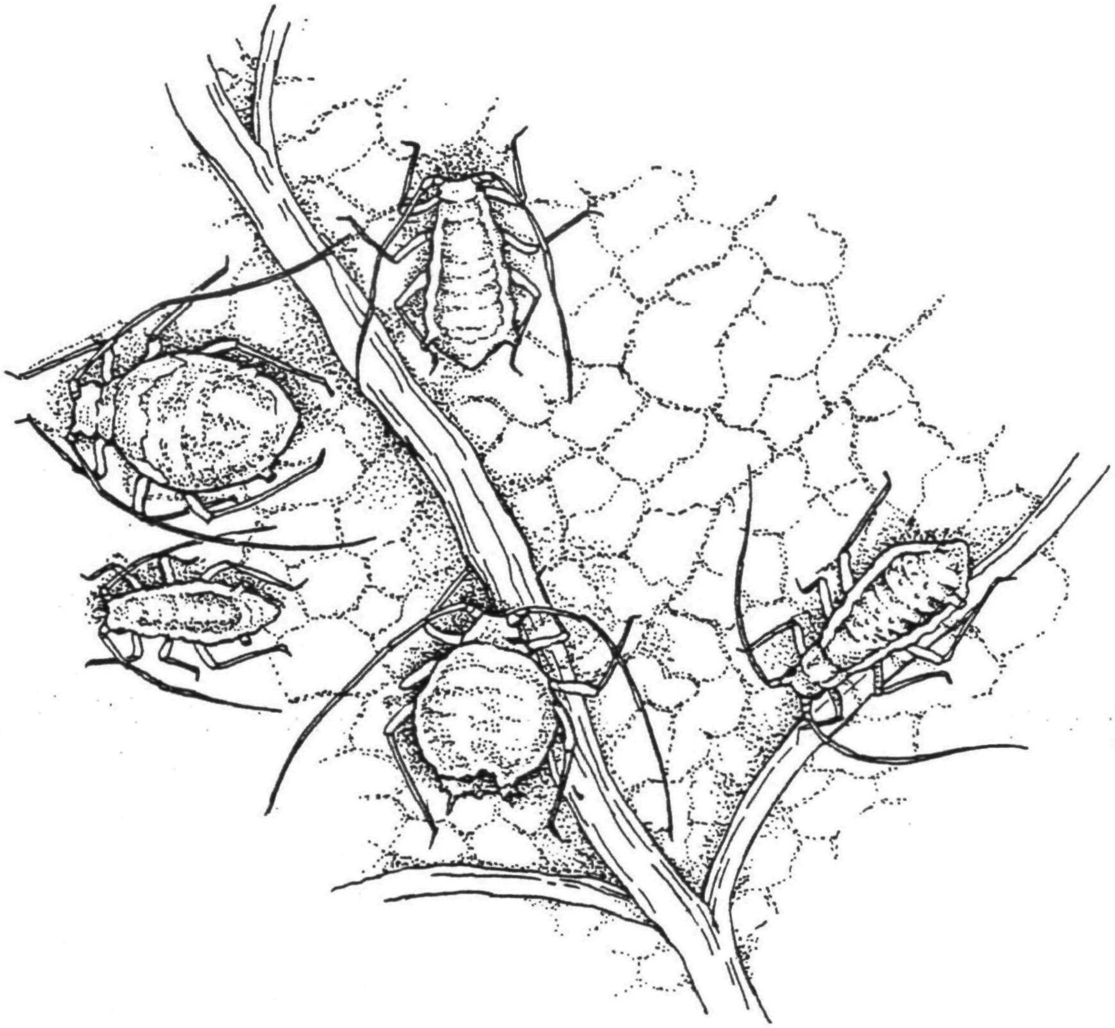


Figure 9. The parasitized aphids or "mummies" can commonly be seen in colonies of live aphids if you look carefully. They are usually shinier and rounder than the live aphid, a different color (tan, white, or black) and stiff appearing.

II. If Natural Controls Are So Great, Why Don't They Work?

You might feel inclined to ask this question if you are currently battling some damaging or annoying pest problem. The answer is that natural controls do work, all the time. In fact, the numbers of species of potential plant-feeding insects are so great that if most of them were not under good natural control, they would have long ago denuded the earth of plant life, making their further survival, along with our own, impossible.

However, at certain times, in certain places, specific animal populations may grow so large that they become a problem. What can account for this?

One reason is that sometimes their parasites and predators cannot find them. Inside the house or greenhouse, for example, aphids, mealybugs, whiteflies or spider mites (see Figure 10) may all become a problem. This can often be solved by setting the plant outside for a few days until the natural enemies find the pests and control them.

Since all animal populations tend to fluctuate, rising and falling in numbers due to the factors we have mentioned above, occasionally a native insect will become numerous enough outdoors during one or more seasons to cause aesthetic or economic damage. Then the outbreak will subside due to natural controls and the insect may hardly be noticed for a few or many years, after which another outbreak may occur again. An example of this sort of seasonal fluctuation is the periodic rise of the California oakworm (see Figure 11), believed by many to be a native insect. It does have parasites, predators and pathogens which usually keep it in check as long as the trees are not treated routinely with pesticides which kill off these natural enemies of the caterpillar.

Even with these natural controls, however, the populations periodically rise to great numbers and are capable of completely denuding a tree of its leaves. When this happens near the house, people can become upset, either because they expect the tree to remain green, or they object to the sight of the caterpillars and their droppings. This generally occurs in the dry season, thus reducing the water loss by these trees. (Water loss by plants is principally through the leaves.) Furthermore, the caterpillars process the leaves, which are very slow to break down, leaving behind their own droppings which release nutrients back to the tree when the winter rains come. Thus, periodic defoliation of native oak trees may be more beneficial than harmful.

In comparison with these noticeable fluctuations in the size of native insect populations from season to season, the invasion of a foreign insect may result in regular high populations every year. The invading insect has usually left its most important natural enemies behind in its area of origin. Although in some cases predators and parasites of closely related insects may consume some small number of the new invader, the absence of controls that are specific to it usually permits the latter to reach population levels regarded as aesthetically or economically damaging.

Some examples of such pest animal invaders of annoyance to California gardeners are the brown garden snail, the elm leaf beetle, a number of common tree-feeding aphids, such as those on silver maples and crepe myrtles, the newly invaded aphid on tulip trees, and a variety of insect pests of common garden

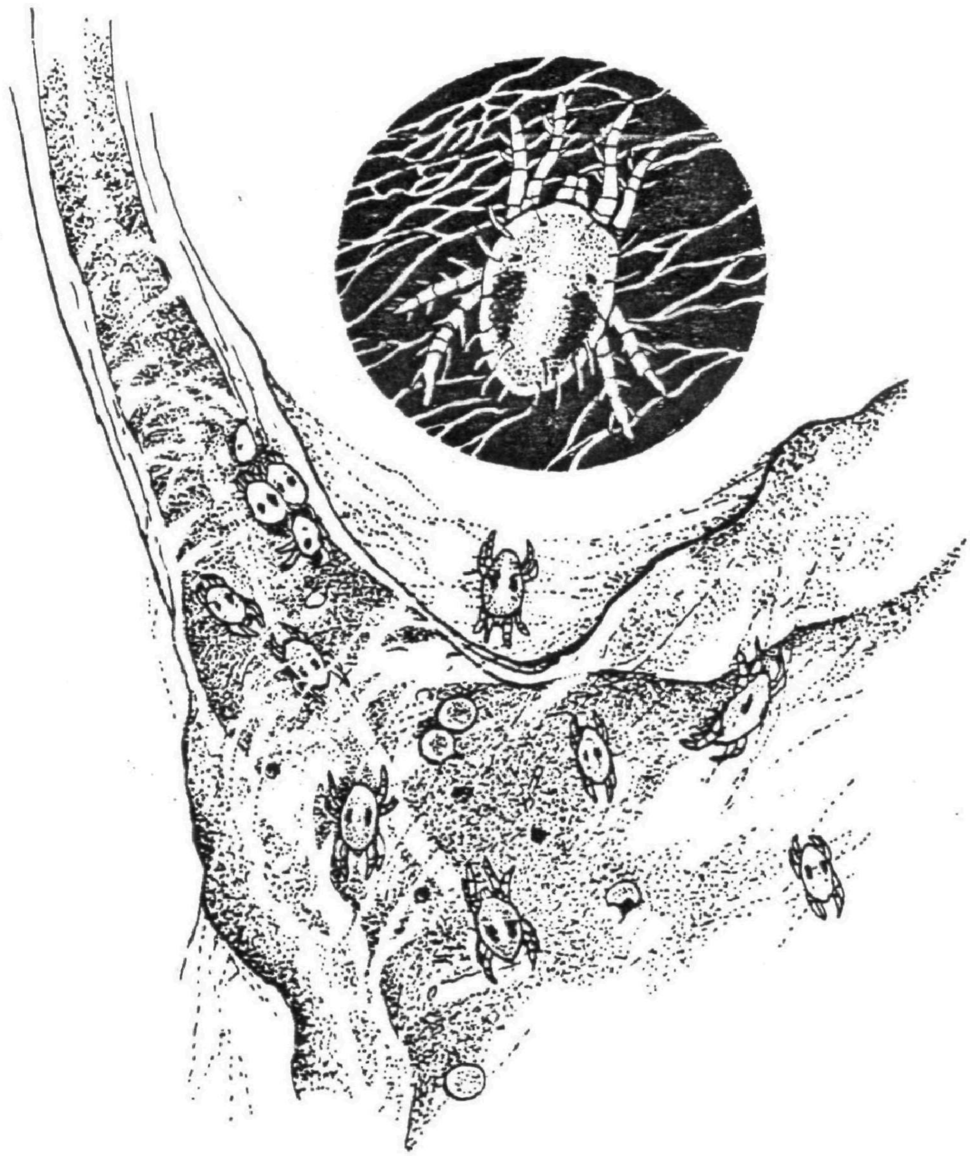


Figure 10. The two-spotted spider mite, Tetranychus urticae, lives within small silken webs, makes very small feeding wounds on the leaves and gives them a speckled appearance. Mite outbreaks usually develop in response to plant stress or disruption of the mites' natural enemies, which are predominantly other predacious mites.

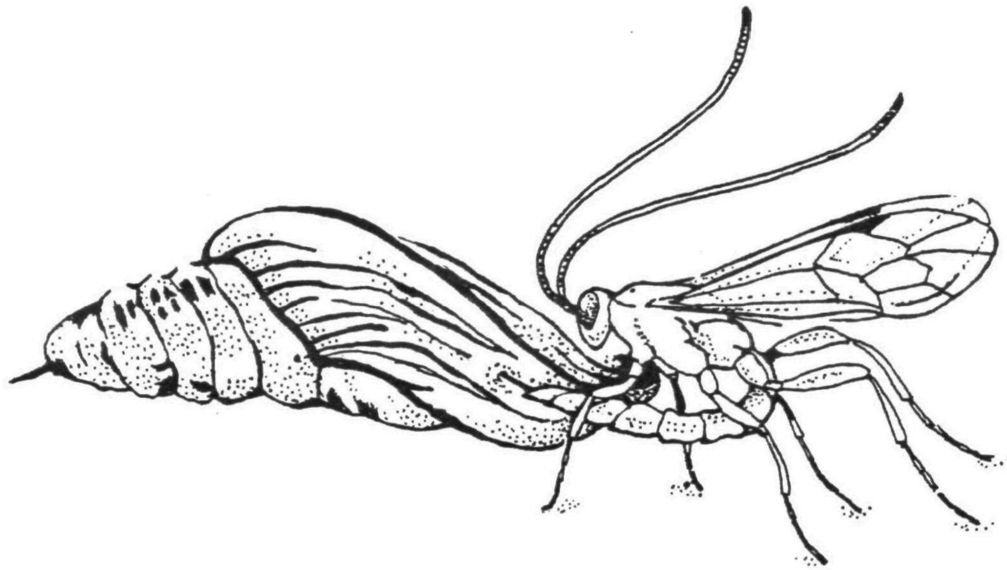


Figure 11. The adult (right) of the California oakmoth, or oakworm, Phryganidia californica, sometimes occurs in large numbers which may be unnecessarily alarming. The above pictures the most important parasite, Itoplectis beherensis stinging the pupal (cocoon) stage of this insect.

vegetables such as the cabbage butterfly, the cabbage maggot (Figure 12) the corn earworm and others. The common household cockroaches and several other important indoor pests are also introduced to this continent from the Old World. The Argentine ant, a frequent house invader when the first fall rains flood its outdoor nests is, as its name suggests, from South America. All these insects have in common that fact that they have escaped all or most of their natural parasites, predators and pathogens.

There is another factor that may account for specific high pest populations on a particular plant: the greater genetic susceptibility of some domesticated plants compared with other closely related horticultural strains or a wild ancestor. A good example in this area is the Modesto ash tree. This is a strain or cultivar,propagated vegetatively (by taking cuttings) from a single tree in Modesto, California. It is more susceptible to both the ash aphid and ash anthracnose (a disease) than other cultivated ashes that resemble it closely, or the native ashes of California and Arizona to which it is believed to be related. A similar phenomenon is seen in agriculture. In general, as vegetables are bred for human consumption, a number of qualities are eliminated that might have served to discourage insect attack in the wild state, for example, strong oils, terpines, resins or hairyness.

Potential pest populations also may be encouraged, or their natural enemies discouraged, by attempting to grow a particular variety of plant in an environment not suited to it. It may simply be too hot or cold, wet or dry for that plant in comparison to its native home. Stressed by an unsuitable environment, the plant may be more susceptible to insect attack or less able to outgrow damage when it occurs. An example would be the susceptibility of the Monterey pine to pine pitch moth when planted in hot, sunny interior locations unlike the cool, foggy coast to which it is native. Bark beetles offer another example of the influence of environmental conditions. Water-stressed trees are more susceptible to damage from these insects. The European earwig (Figure 13) is an omnivore, feeding on other insects as well as plants. They may cause greater damage to seedlings in unmulched gardens, since with bare earth between the plants there is less other food for them.

Free water from dew, sprinklers, etc., and nectar and pollen from shallow-throated flowers, are necessary for many parasitic insects, particularly tiny ichneumonid wasps, which parasitize many caterpillar species. Without this liquid and protein the lives of many natural enemies are shortened and consequently pest numbers may rise. Horticultural settings usually are contrived with a mixture of plant species from many continents brought together in close proximity, often with insufficient consideration of their individual native requirements. Thus it is not surprising that a stable mix of insect and other wildlife populations is difficult to achieve.

Finally, the methods used to deal with the pest may themselves cause the problem to become worse or cause entirely new problems, as described in the next section.

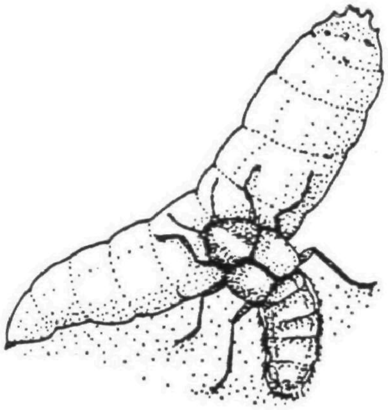


Figure 12. The adult cabbage maggot (Hylemya brassicae) is a fly that lays its eggs near the base of plant members of the cabbage family. When the eggs hatch, the larvae tunnel into the plant roots. This drawing shows a predatory rove beetle in the genus Coprochara feeding on the larva.

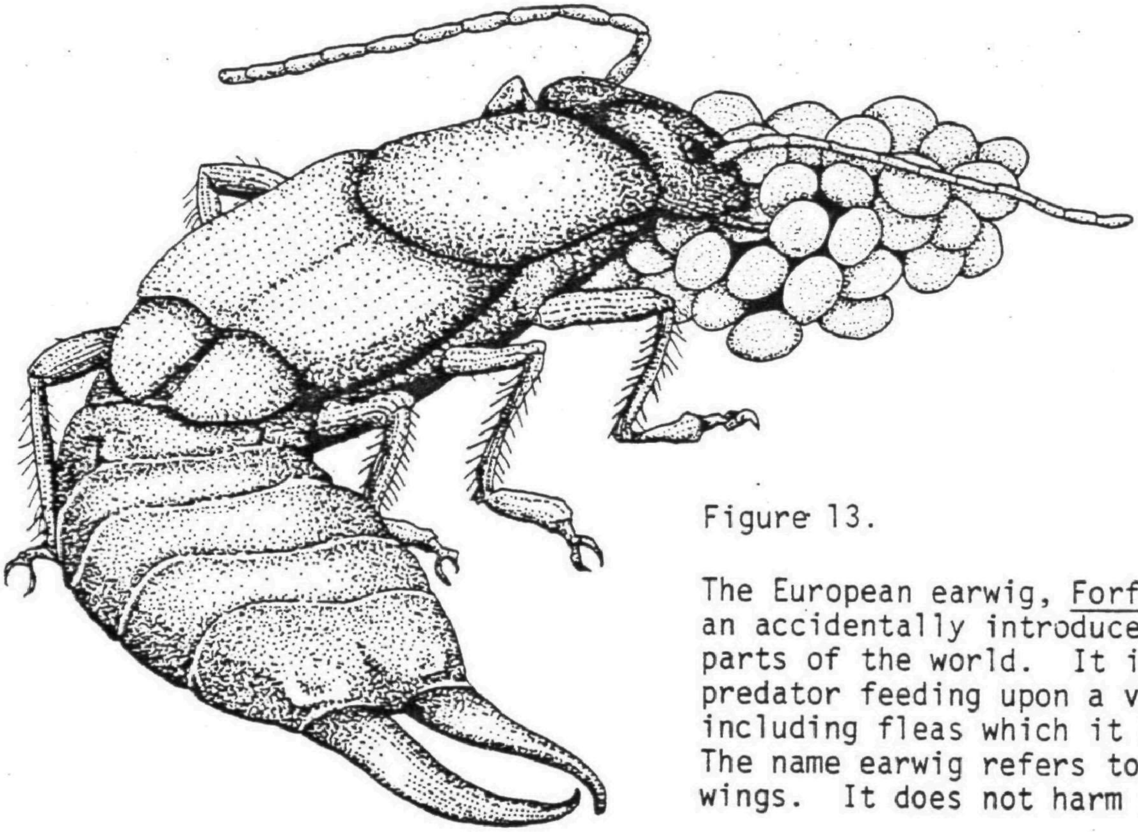


Figure 13.

The European earwig, Forficula auricularia is an accidentally introduced plant pest in many parts of the world. It is also a beneficial predator feeding upon a variety of insects, including fleas which it readily captures. The name earwig refers to its ear-shaped wings. It does not harm humans.

III. What's a Safe Pesticide I Can Use?

When pest problems become intolerable (and sometimes even when they are in no danger of becoming so), the first thing many people want to do is use a pesticide. While theoretically anything that kills a pest might be so designated, usually the term is used to refer to a chemical compound that will kill the target organism when the poison is eaten, inhaled or absorbed through the skin or cuticle. Pesticides may be referred to as insecticides, herbicides, fungicides, rodenticides, miticides, algacides, molluscicides, etc., according to the target pest they are used against. With an increasing awareness among the general public that these compounds can affect humans and other animals as well, people are asking, "What is a safe pesticide to use?" To understand the answer it is necessary to know something more about how pesticides are misused.

The best known of the problems associated with too heavy reliance on pesticides deals with the direct or acute "residue" effects. Warning statements on the label alert users of potential dangers; this is why it should be read thoroughly and directions followed carefully. While most people think of pesticide danger from ingesting the poison, some can be harmful if absorbed through the human skin. Dermal or skin exposure can occur during application of the pesticide, or afterward, through contact with sprayed surfaces. When the pesticide is sprayed into the air, it may cause harm if it is inhaled. Materials used on ornamental plants, such as roses, may be quite unsuitable for use on vegetables because of the danger of eating the poison along with the food. Carefully read the EPA registered label to find out on what ornamental or food plants the material may be used, the proper dosage and other precautions.

The LD_{50} is the rating used to describe the degree to which a particular compound is directly poisonous. It refers to how much is needed to kill fifty percent of the test animals (usually rats) expressed in terms of milligrams of poison per kilogram of body weight. Thus, the higher the number, the less toxic the compound might be considered.

The toxicity of a compound is independent of whether it is derived directly from plant sources (the "botanicals"), or whether it has been synthesized in the laboratory from petroleum. For example, the pesticide pyrethrum has an oral rat LD_{50} of 200 mg/kg, suggesting that it might be safer to handle than nicotine with an LD_{50} of 50-60 mg/kg, yet they are both botanicals. On the other hand, a laboratory synthesized compound, malathion, for example, has an LD_{50} of 2800 and consequently has been regarded as less toxic to humans and other mammals.

A guide to the toxicity of any particular product can be found on the front panel of the EPA registered label. The most toxic compounds are those with an oral toxicity up to 50 mg/kg, or a dermal LD_{50} up to 200 mg/kg, and must bear the signal word "Danger". A compound with an oral LD_{50} from 50 through 500 mg/kg must carry the signal word "Warning". Less toxic compounds with toxicity ratings above these latter must be indicated by the word "Caution". Many of the most hazardous compounds have been withdrawn from the market and are only available to specially trained personnel and under specific circumstances. The active ingredient is listed on the front of the label. There are reference books that can give you the LD_{50} and other information you might wish to have about each compound (see Bibliography).

In recent years, however, it has become apparent that the LD_{50} is not the whole story, as far as human health is concerned. Some of the materials that were once considered relatively non-toxic because of their high LD_{50}'s are now suspected of causing birth defects, genetic defects or cancers that develop many years after the original exposure to the compound. Furthermore, very little is known about the synergistic effect of some of these materials, that is, the effect they have when combined with other compounds, e.g., pesticides along with the common air pollutants of the cities.

In addition, when considering how safe a material is, one has to look at its effects on the environment. Inevitably, in the use of most poisons, considerable amounts fall upon non-target organisms, plants and other animals. Since a healthy garden is teeming with life, both above the soil and within it, there can be all kinds of undesired side effects from using a particular material. Fungicides used against a plant disease may fall upon the ground and inhibit the growth of beneficial fungi, called mycorrhyzae, associated with plant roots and important in helping the plant to obtain nutrients. Decomposer organisms, which break down dead plant and animal litter so that the nutrients are once again available for plant growth, may be affected by insecticides used on plants that fall on garden soil.

Some pesticides have been found to accumulate in food chains. That is, small amounts of poison distributed over plants or plant-eating animals are concentrated in the bodies of organisms that eat them, until finally at the top of the food chain, the animals may be sickened directly or suffer impaired ability to reproduce. In one classic case, small fish absorbed pesticides from contaminated waters through the microorganisms they fed upon. These fish were fed upon by other fish and the brown pelican, a fish-eating bird at the top of the food chain, suffered a serious population decline due to the effects of these accumulated poisons. This is one reason why a whole series of long-lasting compounds, starting with DDT, were withdrawn by the Federal government from regular use by the public. Since humans are at the top of numerous food chains on this planet, the long-term health consequences of using these pesticides were feared. DDT is an example where relying upon the direct toxicity of a pesticide, as expressed as LD_{50}, is inadequate, particularly in determining if the compound will biomagnify, as food chain contamination has come to be called.

The above described direct effects of pesticides upon the health of humans or other non-target animals have been well publicized. Less well-known are the ways in which injudicious use of these materials can disrupt the management of pest populations. The most obvious example of this is when the pesticide inadvertently kills off the natural enemies of the pest (Figure 14), allowing the latter to resurge to even greater numbers than before treatment. A second pesticide treatment may cause an even quicker pest return until you are treating repeatedly with less and less long lasting results. This can easily be demonstrated with aphids on roses or with whiteflies on many ornamentals and vegetables. It is never possible to kill off all of the pests, and even if it were, there are al-

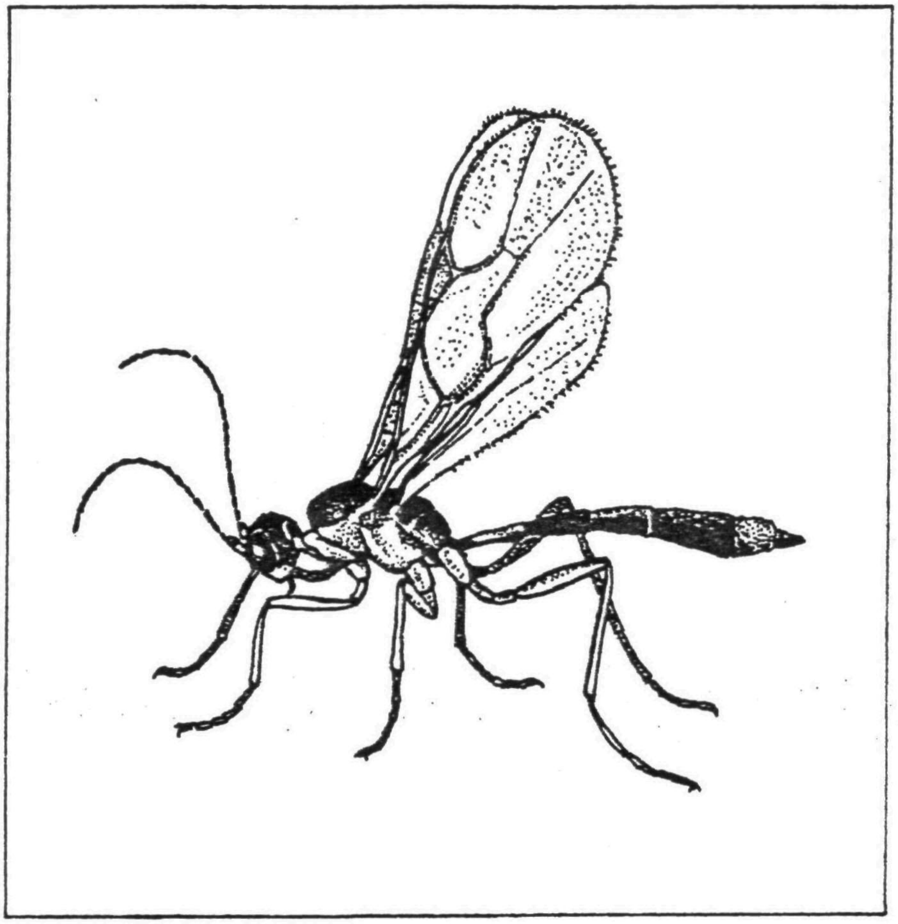


Figure 14. This mini-wasp is a parasite of an aphid. It lays its eggs in the aphid and later emerges from the mummy. When unmated, only males develop from its eggs but when mated both sexes can develop.

ways others that can fly into the area. Since the parasites and predators of the pest insects are fewer in number than their prey, usually slower to reproduce or disperse, and sometimes more susceptible to the poisons, it is easy to see how a pesticide treatment might actually make the problem worse instead of solving it. The insecticide carbaryl is an example of a compound that is particularly harmful to many insect parasites.

With repeated pesticide exposure, a resistant population of pest organisms may develop. This is because each time a spray is used, some of the insects surviving to reproduce the next generation are those that received a dose but were somehow able to detoxify the poison. With each treatment their numbers increase compared with those that survive by merely managing to avoid contact with the poison. Gradually it becomes harder to reduce pest numbers by spraying. People often report increasing the frequency of treatment and the strength of the dose, yet the insect populations, such as cockroaches or whiteflies, are back again sooner and in greater numbers than before. When dealing with pests that can transmit diseases to humans or domestic animals, such as mosquitoes or rats, two pest animals among which resistance to certain pesticides has become a problem, the consequences can be very serious. This is one of the best reasons for using pesticides only as a last resort after all alternative methods have been tried. That way, when a pesticide is necessary, it is more likely to be effective.

Although one is usually conscious of one or two potential pest problems on most garden plants, in reality there are a large number of other species of plant-eating insects in every environment that are rarely noticed because they are under good natural control by their specific parasites and predators. Thus, there is always the danger that the use of a poison against a pest problem will kill off the natural enemies of other potential pests of which one was not aware. In many cases, these latter animals may suddenly cause secondary pest problems as their numbers increase in the absence of control. In some cases the new pest may cause as great or greater problems than the pest that initiated the original treatment. For example, when spraying oak trees for the California oak moth using a carbamate, severe mite outbreaks may occur.

IV. What Should I Do?

The Theory

In place of relying exclusively on chemical tools to manage pest problems, the safest and surest approach is to learn more about the animal you intend to manage and use a series of strategies to deal with the problem. One of these strategies is to determine just when it is necessary to act at all. Since an abundance of insects and other wildlife is desirable to obtain a natural balance in the garden, the wise gardener soon learns that the sight of a plant-feeding insect, or even many of them, is not by itself reason to panic. The pest insects must be present to keep their natural enemies around. Signs of insect presence - leaves chewed here or there, an occasional imperfect blossom - must be accepted as a natural complement of any healthy garden environment. It is only when the damage is about to become truly intolerable that action must be taken. Then, the least disruptive strategies applied just where needed will insure that the balance is restored once again with minimal side effects in terms of human health or the general environment.

The approach described here is sometimes referred to as Integrated Pest Management or IPM. The potential pests and their natural enemies are observed on a regular basis (called monitoring, scouting, inspecting or checking) and decisions are made about what strategy or combination of strategies to use based on these observations. The actual strategies may involve plant selection, habitat manipulation, cultural or physical controls, methods to enhance beneficial insects already present or to release more into the area. In conjunction with the above strategies, the use of an appropriate pesticide confined to a particular spot where no other method is adequate to prevent intolerable damage may be warranted.

Some Specific Examples

Snails:

These strategies can be orchestrated into an Integrated Pest Management program against the brown garden snail. This snail is a native of Europe, deliberately introduced as a food animal, and presently a serious pest along the Pacific Coast and elsewhere. An effort to manage the pest should begin with habitat modification. Since snails breed in moist shady conditions, in beds of ivy, on certain succulents, and where boards rest upon wet soil, these areas should be reduced as much as possible. Fine dry sawdust can be placed under boards used as walkways in muddy areas in the garden. Some gardeners have reported a substantial reduction in damage to seedlings from encircling them with a tin can barrier. The can is opened at both ends and pressed down into the soil around the seedling. If the soil is moist, it can be pushed in an inch or so. This offers a fairly effective barrier to passing snails while the plant is young. Another physical barrier can be made with aluminum screen.

Overturned clay flower pots make effective traps if they are set close to the shady side of a plant and the ground surface is sufficiently irregular to permit the snails to glide in under the rim. During the warm part of the day the snails will collect inside the pots from which they can be removed periodically and killed. In general, handpicking is one of the safest and surest methods of ridding many animal and plant pests from a small area. Snails and slugs are ideally susceptible to this method of control since most are large enough to pick up or squash easily. If you are squeamish, wear garden gloves. When collecting snails for eating, feed them for a few days on clean vegetable material or corn starch to clear out any garden grit from their alimentary system before cooking. They are regarded as a delicacy in many areas of the world.

Finally, if these non-toxic methods do not give a sufficient degree of control, you may wish to make judicious use of a bait. An effective bait contains the active ingredient, ferrous ammonium sulfate. It degrades to a fertilizer. The active ingredient in the most commonly available bait is metaldehyde. Metaldehyde (sold under various trade names) is an organophosphate. Since it is poisonous to dogs, if they are allowed in the area, care should be taken to place the bait inside a receptacle to which they cannot get access, for example, a flattened tin can placed among the plant stems. In any case, the poison should be used only during the part of the season when the damage is severe and confined to those areas of the garden where the plants are seriously susceptible. The pellets may last longer than the powder. Apply pellets after rains or after watering. Excessive moisture reduces their effectiveness. There is always the danger that where large amounts of the poison are used, a resistant local population of snails may develop. Metaldehyde resistance has been reported and thus this bait already may be useless in your area. In any case, read the directions on the EPA registered label before using any pesticide.

A regular checking of the garden for damage while removing snails from the flower pot traps is one way to monitor the size of the snail population and determine where additional efforts are needed. The combination of strategies, habitat modification and plant selection, barriers and traps, handpicking and baits, together with monitoring combine to make an integrated pest management program against the garden snail.

Aphids, Mealybugs, Scales, Whiteflies:

These insects excrete a sugar-protein mixture called honeydew. Honeydew was probably the original "manna" from heaven of the Bible and may drip from the trees when producer populations are heavy. A black "sooty mold" may grow upon the honeydew, like mold in a jelly jar.

In controlling these honeydew producers, exclude ants whenever possible. Ants will protect the honeydew producers from their natural enemies in order to harvest the sweet sugar-protein secretions (see Figure 15). Trees and shrubs with a single or few stems can be ringed with a sticky material such as Stickem[R] or Tanglefoot[R] (not a poison, but an adhesive). Caulking their entrance holes with putty will exclude ant invaders from house plants. Ant baits are sometimes effective in reducing ant activity on aphid or scale infested plants, but it is essential to hide the bait containers away from children who might be tempted to play with them. Available baits frequently don't work against the Argentine ant, so any materials used should be carefully observed to see if they are effective.

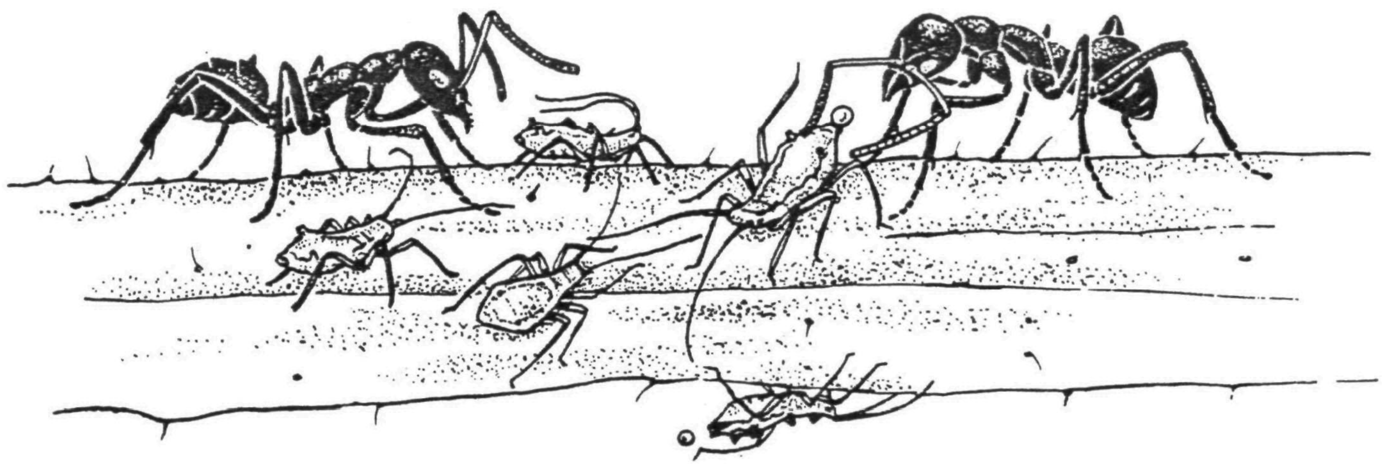
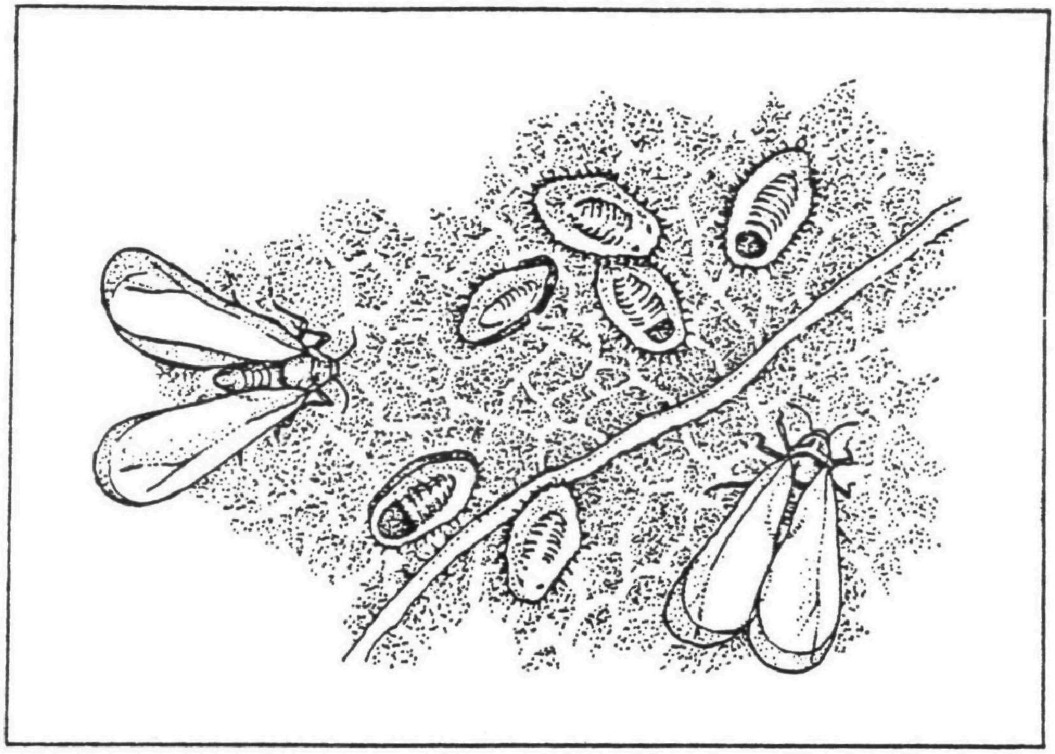


Figure 15. Ants frequently harvest honeydew from aphids (as well as from other honeydew producers) and actively protect them against their natural enemies. Thus protected, the aphid populations can increase, which in turn produces overabundant honeydew. Honeydew can be used as a food, and is believed to be the "manna" of the bible. It is still collected from certain scale insects in the Middle East and sold as a candy in the bazaars.



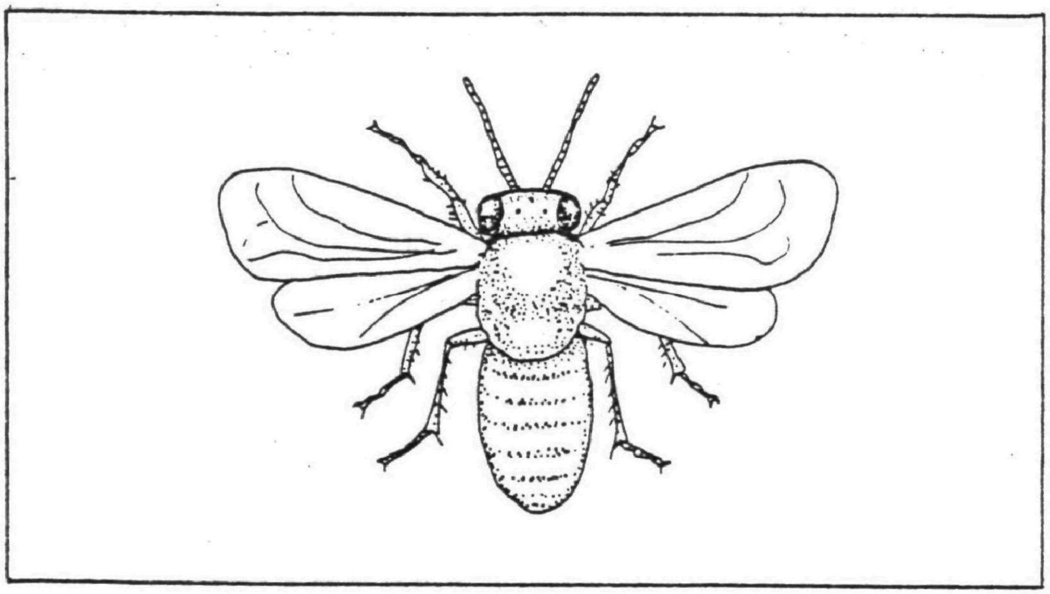


Figure 16. The greenhouse whitefly, Trialeurodes vaporariorum (above) looks like a tiny white fly in the adult stage. As a developing larva, it looks much like a scale - which is attached to the leaf and cannot move. Below is the adult Aphelinid parasite Encarsia formosa which is used to control white flies in Europe.

Water washing the plant is very useful in cleaning off aphids and their honeydew, especially early in the season when the aphids are young, few can fly and most of their natural enemies have not yet arrived. Water washing at this time will not harm the natural enemies. Heavily affected parts of a plant may sometimes simply be pruned off and composted. Those colonies clustered on plant tips can be crushed by hand. During the warm season , house plants can be set in a sheltered area outside where the natural enemies may find the pests. Indoors, house plants can be inverted over a basin and washed with soap and water to clean off aphids, while scales and mealybugs can be rubbed off with a cotton swab dipped in alcohol.

In the greenhouse, green lacewings (Chrysopa carnea) can be bought and released against aphids. Whiteflies, another indoor pest, have a parasite, Encarsia formosa, specific to them which is also available commercially. (See Figure 16.)

Bees, Wasps:

Both bees and wasps are very beneficial (Figure 17). Bees pollinate our crops and the common garden wasps are important predators of caterpillars and other insects. Avoid wearing perfumed cosmetics or using soaps and shampoos with strong odors if you must move around where bees are abundant and active. Yellowjackets can be lured away from the picnic table by bits of tuna fish, raw liver, or cups of sweetened fruit-flavored soft drinks placed at a safe distance. If you are highly allergic to insect stings, consider getting treatments that desensitize you.

Caterpillars:

When the caterpillars are large and easy to reach, as with the tomato hornworm, handpicking is the easiest solution. More thorough searches are needed for the cabbage worm. Large wasps and yellowjackets should be protected when possible as they are important in controlling many common caterpillars on vegetables and ornamentals. Searches at night with a flashlight are frequently necessary when suspecting cutworms (see Figure 18). Pruning out tent caterpillars in trees is effective.

B.t., short for Bacillus thuringiensis, is a useful tool in managing high populations of a number of caterpillars, common and annoying in this area, such as oak moth, tent caterpillar, and fruit tree leaf roller. It is a naturally occurring disease of these insects, produced commercially for many years in this country, and sold under several trade names. It is in many ways preferable to other common materials used against these insects because it will not harm their natural enemies and is non-toxic to people, pets, other domestic animals and wildlife. Thus it cannot cause outbreaks of other pests through killing off the beneficial predators and parasites.

B.t. is a living material that must be kept in a cool dry place. It will store the longest in the wettable powder form. It should be applied to the leaves of the plant at the time when the caterpillars are large enough to be eating through the leaves. This increases the likelihood that the larvae will consume a toxic dose. When spraying the material on the plant it is

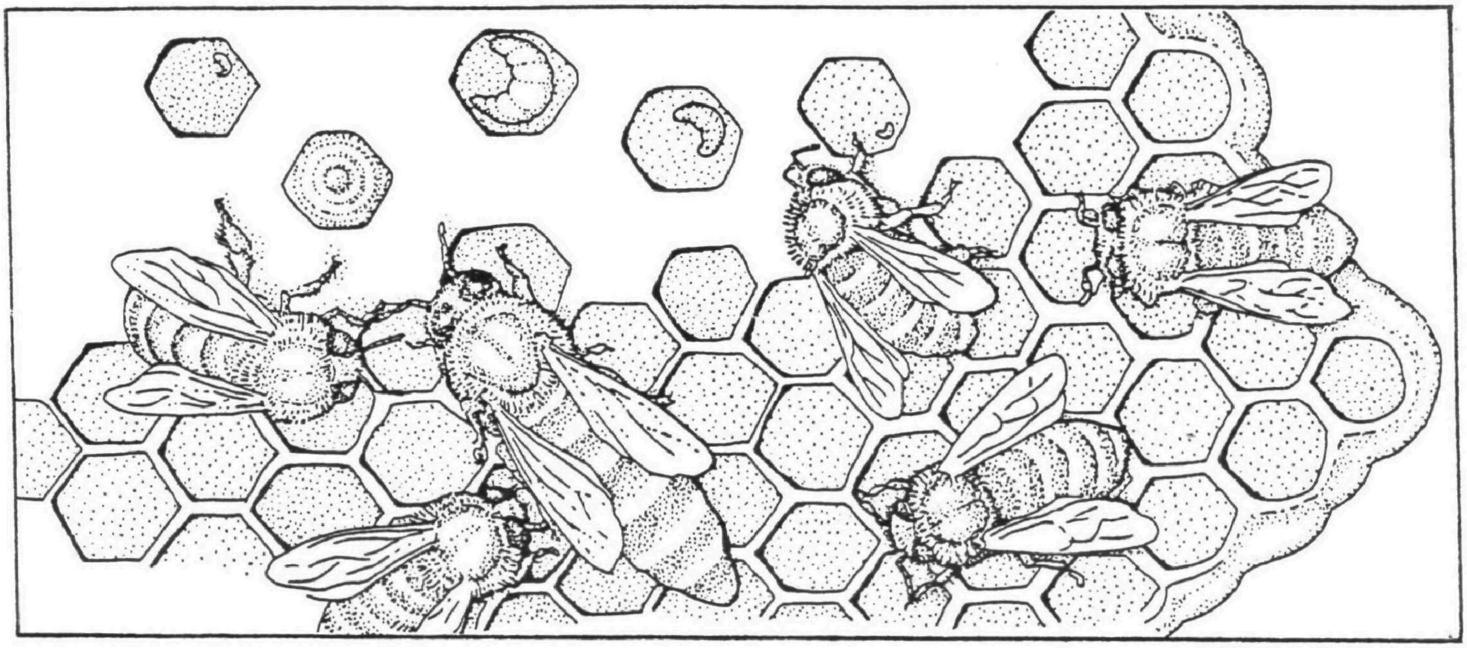
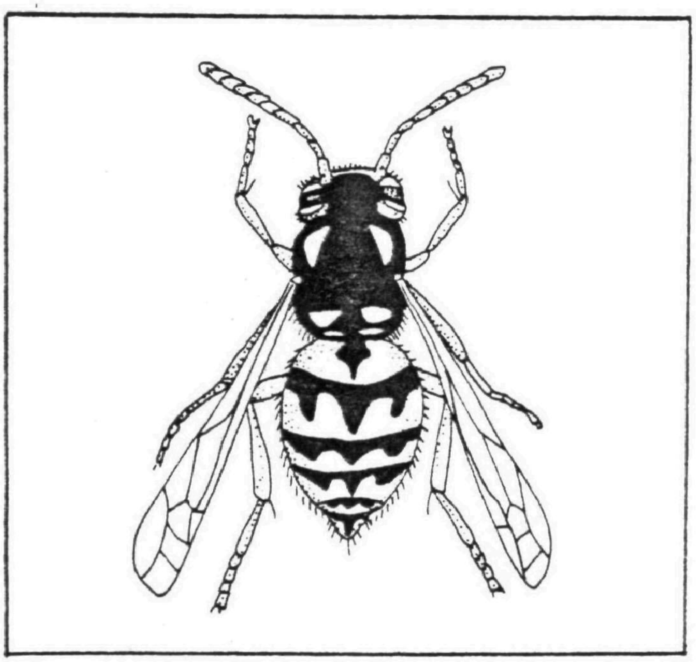


Figure 17. Above: bees on their combs. The large one is the queen. Below: a predacious wasp. All bees and wasps are beneficial yet can sting if provoked.



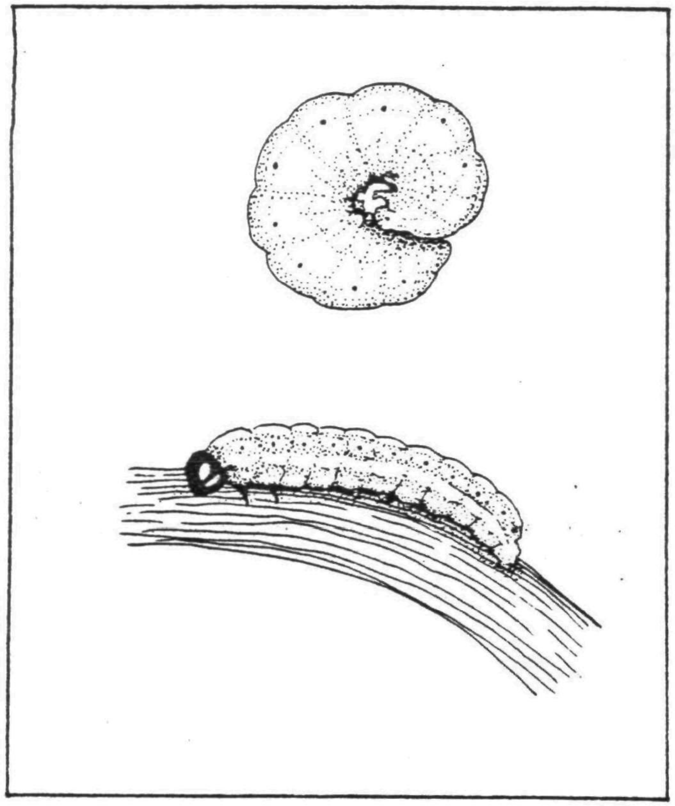


Figure 18. Suspect cutworms (the larva of a moth) when seedlings have been snipped off near ground level. Search for them at night on the plants or in the day curled up nearby in the mulch.

easy to miss coating both sides of the leaves and, when the caterpillars are young and feeding only in a restricted area, sufficient numbers may not encounter enough B.t. Since the B.t. must be eaten by the insect to have an effect, and the adult moths do not eat the leaves, there is no point in spraying when the moths are flying. Furthermore, there is no way to know at the time when the moths are laying eggs whether a sufficient number of the caterpillars will ever live long enough to cause any damage. During most seasons in most areas their many natural enemies will keep the numbers of caterpillars down to where the damage, if noticeable, is still tolerable.

Follow directions for use on the particular EPA registered label for timing and method of treatment, insects controlled and plants to which a B.t. product may be applied.

Cabbage Maggots, Garbage Flies:

Exclusion whenever possible is a useful defense against adult flies. Use window screens on the house. In the garden use screened enclosures to protect the cabbage family plants against the fly whose young is called the cabbage maggot. Once flies are in the house, the fly swatter and the string of fly paper are still the best methods of killing the flies and protecting your health at the same time. Ultimately, however, preventing the production of flies is the key to successful management.

Common house flies develop in organic wastes. In warm weather the average garbage can may produce over a thousand flies a week. The answer is to manage organic wastes properly. Place kitchen garbage in tightly closed containers until it is picked up through the city refuse collection. Or, better yet, learn to store and compost it properly so that smells do not attract adult flies to lay eggs and so that the high temperatures of the compost kill any eggs and larvae that are present. For further information on composting methods suitable for use in urban areas, see the Bibliography.

Cockroaches, Ants, Food Moths, Fleas, Rats:

The first step with all these pests is exclusion. Indoors, place food in jars. Use tops that seal with an inner liner in the cap or a rubber ring. Caulk up cracks through which ants enter and in which cockroaches hide. Caulking compounds will handle the large cracks, latex paint the finer ones. Use cement, screen or hardware cloth to close off all gaps around pipes and electric or other lines where they enter the house. Similarly screen off with hardware cloth all ventilation or other holes in eaves in attic and basements through which rodents can enter.

Outdoors, place garbage in cans with tight lids, stack wood neatly and clean up junk heaps where rodents may nest. Do not leave cat and dog food out all day. (Figure 19) Feed as much as the animal will eat at one time and remove remains until the next feeding. If your compost is not kept in a bin and turned regularly so that it heats up, use only garden debris within it and avoid adding kitchen garbage. If you do use a hot compost for managing organic wastes, then add to it any dog manure you may find. Such droppings, when left uncomposted, can provide food for rats.

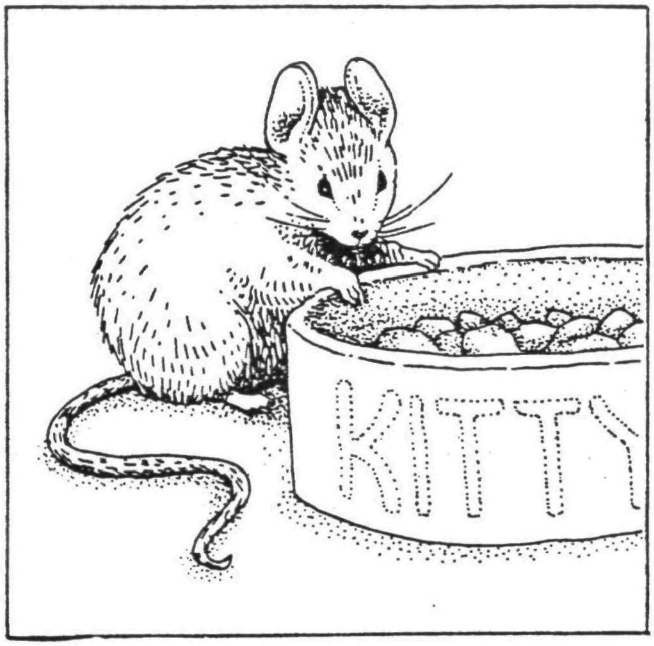


Figure 19. A young rat, Rattus rattus feeding at the pet food bowl. Rats gain entry to the house through various openings such as around pipes, electric lines and sewers (through toilets).

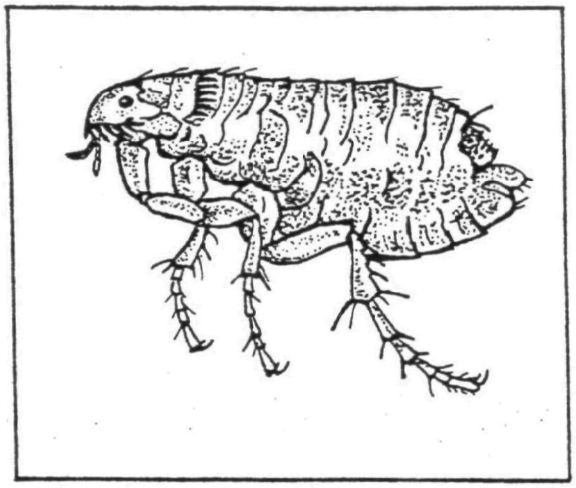


Figure 20. Usually it is the cat flea, Ctenocephalides felis that is pestiferous on humans and dogs. The dog can also have the dog flea, C. canis, Fleas are vectors of disease. The oriental rat flea can transmit bubonic plague and typhus, the dog flea, tape worms.

Fleas (Figure 20) are usually only a serious problem in the late summer and early autumn. Prepare for this by doing your spring cleaning in late summer. Thoroughly vacuum and wash all floors, rugs and other surfaces to which your pets have access. Ideally the contents of the vacuum cleaner bag should then be composted, burned, frozen, or emptied into a garbage can. This will pick up both adults and developing larvae as well as remove their food sources. Giving a dog a combing or bath also is a good idea. If the infestation becomes so bad that you feel you must use a flea collar on your pet, use it only during the time populations become intolerable, removing the collar and storing it in a small air-tight jar in the freezer until the next time it is used. Flea collars send an insecticide into the air that disrupts transmissions of nervous signals. Although this vapor is invisible, remember that it is being emitted and is a poison. Such products should be approached with caution.

Dutch Elm Disease - The Difference Between Elm Bark Beetles and Leaf Feeding Beetles

The Dutch Elm Disease is caused by a fungus which came originally from Europe, spread slowly across the country and reached California in 1975. The most common symptoms of the disease are a sudden paling of the vegetation on the uppermost limbs, and death of those limbs and eventually the entire tree. The fungus is spread by elm bark beetles that live just under the bark of certain species of elm trees when they are weakened or dying. During a brief period in each generation, the elm bark beetles fly to and feed on healthy non-diseased trees. It is during this time that the fungus spores carried on their bodies may brush off and infect other elms. The beetles then return to the weakened or dying trees to lay eggs. There may be two full generations per season. The best approach is to make sure that all dead or dying elms or elm branches are carefully removed and destroyed. All cut elm wood should be burned immediately, or the bark removed, so no sites remain where the beetles might lay their eggs. Beetles in removed bark from diseased trees should be destroyed.

Do not confuse the elm bark beetle, which is rarely seen on the leaves, with the elm leaf beetle (Figure 21) which is common and highly visible on many elms and can cause serious defoliation. The latter beetle, an invader from Asia, lays its eggs on the leaves, has several generations per year and at the end of the larval stage, crawls down the tree to pupate around the base. An active project to control this latter insect using its natural enemies is presently underway in California. The elm leaf beetle is not a sign that a tree has Dutch elm disease.

You should become aware of dead and dying branches and/or a generally unhealthy look to the leaves of your elm, and, if you suspect Dutch elm disease, call your county agricultural commissioner's office or the street tree department of your city and ask for guidance on managing the situation.

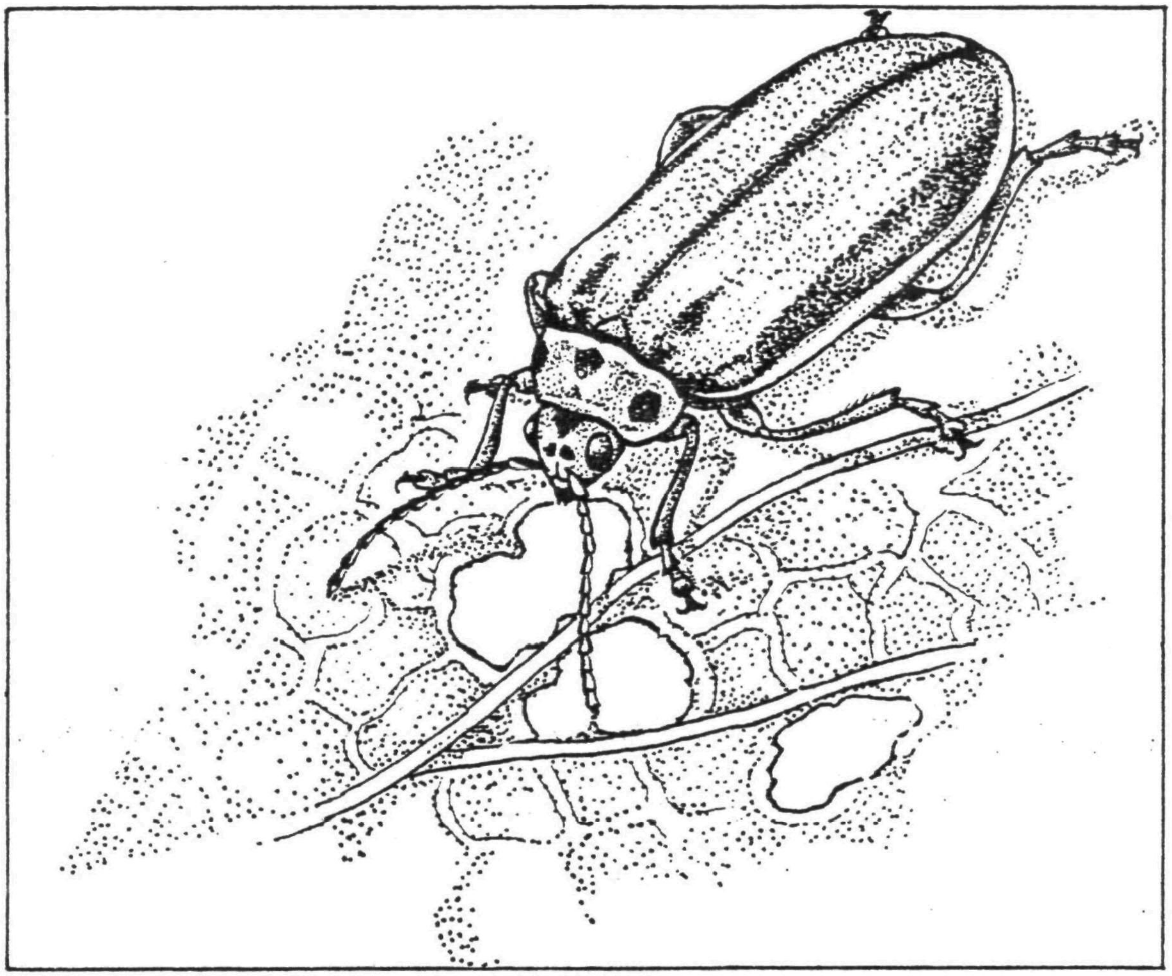


Figure 21. The elm leaf beetle, Pyrrhalta luteola, feeds on the leaves of most elms. Probably originating from the Middle East, it is a major pest problem in Europe and the United States.

V. Summary of Control Methods

To develop a sound pest management program for your home and garden, first consider the alternative strategies in the following order:

1. Plant selection. When possible, plant varieties that are somewhat resistant to the potential pests in your area.

2. Cultural controls. See if modifying your watering, fertilizing, pruning or other methods of plant care will reduce the numbers of pests, or enhance the pests' natural enemies or the plant's ability to outgrow the damage.

3. Habitat modification. Determine if changing the environment in some manner will reduce the problem, by either discouraging the potential pest, or encouraging its natural enemies; e.g., mulches, removing or adding nearby plants, modifying wind or light conditions, etc.

4. Physical controls. Pick off and kill the pests by hand when possible, at night with a flashlight or in the very early morning when the insects may be too cold to move away from your grasp easily. Vacuuming will work for large congregations at the doorstep or windowsill. Washing and vacuuming will clean up flea larvae.

5. Barriers. Screens, nets, sticky materials and similar barriers are frequently appropriate for keeping potential pests out of the garden or the house or away from specific plants.

6. Traps. The potential pest may be lured into a trap by light, smells, pheromones (insect attractants), darkness, etc. Observe the behavior of the animal you are trying to trap, or read something about it.

7. Baits. Baits may be used to bring the potential pest to a trap or to kill it outright. Poison baits are always preferable to sprays or drenches since less of the environment is affected by the toxic materials. If they are properly chosen and placed, the impact on the environment should be minimal.

8. Biological control. Most of the above methods are designed to conserve the naturally occurring biological controls already in your environment. In some cases these may be enhanced by providing habitat, food or water, e.g., bird nesting sites, overturned flower pots for ground beetles, etc. In some cases release of lacewing eggs or larvae, or *Tricogramma* mini-wasps, may be helpful to augment the biological controls already present.

If no alternatives work adequately, the damage is severe and you choose to use a pesticide:

1. Choose the least toxic materials, e.g., water, soap and water, and pesticides with the signal word "caution" on the label.

2. Choose selective materials whenever they are available, e.g., *Bacillus thuringiensis* sprays, or baits against certain caterpillars.

3. Read the labels of all pesticides carefully. Follow the directions given on how to protect the applicator and the environment, mix only the amount you will actually need (if you will use half a cup to spray one branch, don't mix a gallon and spray the yard), and clean up appropriately afterward.

In the last analysis no single technique will solve a pest problem over the long term. Combinations of techniques used together, timed properly and called into play when injury levels will be exceeded, is the best approach known to manage pest problems.

VI. How Can I Get More Information?

An excellent book on controlling insects on house plants is Windowsill Ecology, by William H. Jordan, Jr., Rodale Press, Inc., Emmaus, Pennsylvania, 18049.

Good books to be consulted by lay gardeners interested in getting bugs identified are Insect Pests of Farm, Garden and Orchard, by R. H. Davidson and L. M. Peairs, John Wiley, New York City; and A Field Guide to the Insects, by D. J. Borror and R. E. White, Houghton Mifflin Co., 6th edition.

For information on composting methods that reduce fly production, see The City People's Book of Raising Food, by Helga and William Olkowski, Rodale Press, Emmaus, Pennsylvania, 1975.

A detailed discussion on using non-toxic methods to control pests inside the home, in the garden and in small-scale greenhouses is found in The Integral Urban House, by Helga Olkowski, William Olkowski and Tom Javits, Sierra Club Books, San Francisco, California, 1979.

To determine the LD_{50}, the chemical name and other characteristics of common pesticides, see the Pesticide Index by W. J. Wiswesser, Editor, Entomological Society of America, 4603 Calvert Road, Box AJ, College Park, Maryland, 20740.

The Pesticide Division of the regional branch of the Environmental Protection Agency can answer many of your questions about the pesticides and their use. City, county and state health departments can also be contacted.

The local cooperative extension office may be helpful in providing information about alternative methods of pest management if specifically requested to do so. Your local library or city maintenance departments may also be good sources of information.

VII. Scientific Names of Common Insects, Insect Families and Other Pests Mentioned in the Text, and Pages Where They Appear

	Scientific Names	Pages
ants, in general	family Formicidae, many species	24, 25, 30
Argentine ant	*Iridomyrmex humilis*	17
aphids, in general	Aphidoidea, more specifically Aphididae, many species	4, 7, 8, 12, 13 14, 17, 20, 21, 24, 25, 27
ash aphid	*Prociphilus fraxinifolii*	4, 17
bees	family Apidae, many species	27, 28
brown-banded cockroach	*Supella longipalpa*	17, 22, 30
brown garden snail	*Helix aspersa*	7, 8, 14, 23, 24
brown lacewing	family Hemerobiidae, many species	7, 35
cabbage butterfly	*Trichoplusia ni*	17, 27
cabbage maggot	*Hylemya brassicae*	17, 18, 30
California oakworm	*Phryganidia californica*	14, 16, 22
caterpillars, in general	order Lepidoptera, many species	14, 17, 27, 29, 30
crepe myrtle aphid	*Melanocallis kahawaluakalani*	14
convergent ladybeetle	*Hippodamia convergens*	7, 8
corn earworm	*Heliothis zea*	17
cutworm	family Noctuidae	29
earwig	Forficula auricularia	17, 18
elm bark beetle	*Scolytus multistriatus*	17, 33
elm leaf beetle	*Pyrrhalta luteola*	7, 10, 11, 14, 33, 34
fleas, in general	order Siphonaptera, many species	18, 30, 32, 33, 35
food moths	e.g., Mediterranean flour moth *Ephestia (Anagasta) kuhniella*	30
garbage flies	usually, *Phaenicia sericata*	4, 5, 6, 30

Table VII., cont'd.

	Scientific Names	Pages
green lacewing	family Chrysopidae, more specifically, _Chrysopa carnea_	7, 27, 35
ground beetles	family Carabidae, many species	7, 9
hover flies	family Syrphidae, many species	7, 9
mealybugs	family Pseudococcidae, many species	14, 24
mealybug destroyer	_Cryptolaemus montrouzieri_	7
mites, in general	class Acarina, many species	14, 15, 22
mosquitoes, in general	famly Culicidae	22
parasitic insects	order Hymenoptera, Diptera and others, many species	5, 10, 11, 12, 13 16, 17, 20, 21, 22, 26, 27, 35
pine pitch moth	_Vespamia_ sp.	17
predatory bugs	order Hemiptera, Anthocoridae, and others, many species	7, 9, 10, 22, 25
rats	_Rattus_ sp.	19, 22, 30, 31
rove beetles	family Staphylinidae, many species	7, 9, 18
scales, in general	family Coccidae, many species	24
silver maple aphid	_Drepanaphis acerifolii_	14
spider mite	_Tetranychus urticae_	14, 15
tomato hormworm	_Protoparce quinquemaculata_	4, 5
wasps	family Vespidae, many species	27, 28
whiteflies, in general	family Aleyrodidae, many species	14, 20, 22, 24, 26, 27