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Household Pest and Rodent Control

Classification 2

Training Manual

DIVISION OF AGRICULTURE
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Household Pest and Rodent Control

Edited by

Dr. John D. Hopkins, Associate Professor and Extension Entomologist, University of Arkansas Division of Agriculture.

Contributors

Dr. John D. Hopkins, Associate Professor and Extension Entomologist, University of Arkansas Division of Agriculture.

Dr. Becky McPeake, Professor andExtension Specialist-Wildlife, University of Arkansas Division of Agriculture.

Preface

This manual provides information for the Arkansas commercial pesticide applicator wishing to become certified in Household Pest and Rodent Control – Classification 2. To become a certified applicator in this category, a candidate must pass both a general standards exam and pass an examination based primarily on the material presented in this manual and (Circular 6) Arkansas Pest Control Law (Act 488 of 1975, as amended). Information covered in the general standards examination is contained in "A Guide for Private and Commercial Applicators: Applying Pesticides Correctly." Refer to (Circular 6) Arkansas Pest Control Law (Act 488 of 1975, as amended) for specific requirements. The Arkansas State Plant Board administers the examinations. Up-to-date study materials can be obtained from the Arkansas State Plant Board, #1 Natural Resources Drive (P. O. Box 1069), Little Rock, AR 72203-1069, phone (501) 225-1598. Additional study information may be obtained from the University of Arkansas Cooperative Extension Service, the pesticide label, current publications on the subject, pesticide distributors and manufacturers.

Acknowledgments

Information accumulates from direct observations, scientific literature and anecdotes from others. Information from these sources blurs together quickly, and consequently, unique ideas are rare in society. Credit for sources of information on urban pest control and management must go to:

> Land grant university Extension and research workers, most entomologists, who pioneered this work, those who kept training and research alive during the period when the success of synthetic organic pesticides preempted nearly all but control evaluations from the 1940s to the 1960s, and those who persist today; pest control industry workers who held training sessions nationally, regionally and locally where information was disseminated among the experienced and provided to the inexperienced; Environmental Protection Agency personnel who molded modern training and influenced the need for national uniformity in training requirements; state regulatory personnel who cooperated with universities and industry and who strongly emphasized the importance of training; and the few textbook authors in the United States and England who compiled the reference data in the understandable and usable form that allows urban pest management practitioners to be professionals.

Portions of this manual have been adapted from commercial applicator certification training manuals for general pest control developed by the Oklahoma Cooperative Extension Service, Division of Agricultural Sciences and Natural Resources, Oklahoma State University; Texas Agricultural Extension Service, the Texas A&M University System; and University of Nebraska Cooperative Extension, University of Nebraska-Lincoln. Also, special thanks go to Dr. Jim T. Criswell and Dr. Melinda Crockett, Oklahoma State University, Oklahoma Cooperative Extensive Service; Dr. Don L. Renchie (Texas Cooperative Extension) and Dr. Grady J. Glenn (Center for Urban and Structural Entomology), Texas A&M University System; Dr. Clyde L. Ogg, Extension Educator-Pesticide Education, University of Nebraska Cooperative Extension; and Dr. Eugene Wood, Department of Entomology, University of Maryland for their assistance in preparation of this training material. Special thanks goes to Florida Cooperative Extension Service for use of portions of their manual including photographic representations.

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Introduction

Learning Objectives:

After completion of the Introduction, the trainee should be able to:

- Know what is expected of you as a General Pest Control Applicator.
- Know how insects transmit human disease.

Expectations of a General Pest Control Applicator

Applicators must demonstrate a practical knowledge of a wide variety of pests, including their life cycles, types of formulations appropriate for their control, and methods of application that avoid contamination of food, damage and contamination of habitat and exposure of people and pets. Since human exposure, including babies, children, pregnant women, and elderly people, is frequently a potential problem, applicators must demonstrate practical knowledge of the specific factors that may lead to a hazardous condition, including continuous exposure in the various situations encountered in this category. Because health related pest control could involve outdoor applications, applicators must also demonstrate practical knowledge of environmental conditions, particularly related to this activity.

How Insects Affect Man

Insects have a long history through many geological periods. They appeared in the world long before man; yet insect fossils from coal, amber and limestone deposits differ little from their present-day descendants of 250 million years. As man appeared on earth and changed, his parasites and pests evolved with him.

Over 750,000 species of true insects have already been described, and it is estimated that we have about 20,000 to 30,000 species of insects in Arkansas. Arkansas also has hundreds of thousands of species of mites, ticks and other close relatives of insects.

For centuries man has fought insects as pests, carriers of disease and destroyers of his food. This combat will continue, for humans have never eradicated a single species. Today, many of the most important species are showing increasing resistance to insecticides. Consequently, other methods of control, either alone or in combination with insecticides, are necessary.

Insects are often thought of as man's most formidable competitors. Not only do they damage crops, but insects such as flies, fleas, lice and mosquitoes directly attack man and domesticated animals. Others attack indirectly by transmitting dangerous diseases to man and animals.

Transmission of Human Disease

Although insect bites or stings occasionally cause severe illness or are fatal to humans and animals, their disease-laden saliva or contaminated bodies are responsible for many illnesses or deaths over the world.

Mechanical or passive transmission of disease occurs, for example, when the housefly merely transports organisms – such as dysentery bacteria on its feet, body hairs and other surfaces – from filth to humans. Other examples include cockroaches and vinegar gnats that visit sewers and liquid excrement and then move to human habitations.

Biological transmission of disease occurs when an insect, such as the bedbug I or flea, mite or tick, is essential for the completion of the life cycle of the disease or parasite. Certain *Anopheles* mosquitoes, for example, are essential carriers and vectors of the malaria parasite. This parasite undergoes a portion of its life cycle in the *Anopheles* carrier and another portion in the human host.

Disease is also transmitted through the host-vector relationship. Such transmission is often further complicated by more than just the direct carrier of the disease from one host to another. Some other hosts called "reservoirs" are not affected by the disease but are able to perpetuate the disease organism by providing safe harborage for the disease organism. Some birds, for example, are reservoirs of mosquito-borne encephalitis

(sometimes called “sleeping sickness”). The birds are apparently unharmed by the encephalitis virus, but when the mosquito sucks blood from the bird and then bites man or horses, the virus may produce serious or fatal results.

Insects generally cannot transmit disease unless they have already bitten a diseased host. For example, an *Anopheles* mosquito cannot transmit malaria unless it has first bitten a person with the malaria parasite (in addition, there is often an “incubation period,” a period between when the disease is picked up by the insect and the time when it is able to transmit the disease). Some ticks and mites, however, are able to transmit disease-causing organisms, such as the rickettsia causing Rocky Mountain spotted fever, directly to their offspring through the egg.

Myiasis is the infestation of man or animals by living larvae (maggots) of flies. Maggots mostly infest dead tissue. An example of the other type is the “true screwworm” which attacks the living tissue of livestock and rarely man. The maggots of some flies, including the rat-tailed maggots of flower flies, may be accidentally swallowed and cause intestinal upsets.

Poison, Irritation and Allergy

Many insects and some spiders, scorpions and centipedes have developed poisoning mechanisms for self-defense or for paralyzing their prey. Stings and bites may be intensely irritating to humans but seldom cause death in Arkansas.

Probably the most dangerous are the bites of the black widow spider, *Latrodectus mactans,* and the sting of a small scorpion, *Centruroides vittatus*, found in Arkansas. The brown recluse spider, *Loxosceles* recluse, is common in Arkansas and may inflict a serious bite, which may result in sufficient dead tissue that skin grafting is needed. Even the stings of bees and wasps may be serious or even fatal to persons highly allergic to their venoms.

Some insects, such as the dermestid beetle larvae, have stiff hairs that when touched feel like stinging nettles. Cantharidin, present in the blood of blister beetles, causes painful blistering of the skin when the insect is crushed. Mosquitoes, fleas, chiggers and other pests have done much to irritate man.

Another, more recent finding concerning insects and allergy is the relation between cockroaches and asthma. Studies have shown that with increased weather-tight buildings, indoor air quality has been lowered and, in structures where roaches are present, cockroach dust will increase the likelihood of childhood asthma.

General Insect Pests

Learning Objectives:

After completion of the study of Pests On or Near Food, the trainee should be able to:

- Given a cockroach specimen, hand lens and pictorial key, identify the specimen by common name.
- Given a list of common cockroaches, match each with its habitat.
- Cite monitoring strategies for cockroaches.
- Given an actual control situation, apply all elements of cockroach management to include sanitation, proper selection of pesticides, application techniques and other control methods.
- Identify key features in the life cycle, habitat and appearance of the common species of ants.
- Given a problem situation for each species of ant, select appropriate control and management procedures, including both chemical and non-chemical.
- Describe the life cycle and habits of common urban flies.
- Given a specimen of a common urban pest fly species, identify its common name or group.
- Given a fly management problem, describe pest management procedures needed to suppress it.

The basics of controlling insects and other pests which attack man or his possessions include pest recognition, understanding its life habits, determining the need for treatment or environmental/ structural modifications, pesticide selection, proper timing and application of pesticides and determining the need to treat again. The following information deals with the most common pests in Arkansas that will likely be encountered on or near food.

Cockroaches

Cockroaches are major pests in homes, restaurants, hospitals, warehouses, offices and other structures with food-handling areas. These insects can contaminate food and eating utensils, destroy fabric and paper products and impart stains and odors to surfaces they contact.

Cockroaches have not been found to be direct carriers of disease; however, they can mechanically contaminate food or utensils by transporting filth or disease organisms on their bodies or by way of their excreta. They are suspected to be associated with the spread of dysentery, diarrhea and food poisoning. They are also associated with allergies and related to some aspects of asthma attacks. Although there are more than 50 species of cockroaches in the United States, only five are considered major pests in Arkansas. These species are the **German, brown-banded, American, Oriental**, and **wood cockroaches**.

Since different species of cockroaches have different habits and habitat preferences, proper identification is essential for control. Cockroaches are mainly active at night but may be commonly seen at other times when infestations are severe. Signs of cockroach infestation are visual sighting of live roaches, fecal droppings, full or empty egg cases (oothecae), cast skins from nymphs, stains and strong musty odors. The use of flushing agents frequently helps to locate cockroach infestations.

Many cockroach infestations begin by the introduction of a few individuals on equipment or other materials from an already infested area. Any suspect objects should be thoroughly inspected. Although this is frequently difficult, the effort may be worthwhile, especially if a structure has a record of recurring infestations.

Sanitation is the key to control. Cockroaches require adequate food, water, shelter and favorable temperatures to survive. Once cockroaches have been introduced into a structure, infestations are likely to build up much more rapidly, be more severe, and more difficult to control, if proper sanitation conditions do not prevail. Accumulations of materials such as garbage, rubbish, boxes, sacks, newspapers, and empty soda and beer bottles should be eliminated. Areas of excessive moisture within a structure should be eliminated. Proper cleaning of areas where scraps of food or grease accumulate is also helpful. In general, anything that can be done to reduce the supply of food, water, or shelter for roaches will reduce possible infestations.

Once a colony of cockroaches has established itself in a structure, proper sanitation will not rid the premises of the infestation. In this case, chemical

control is necessary. Since domestic cockroaches have different environmental habits and biologies, the method and extent of chemical treatment should vary by species.

General Characteristics and Life Cycle of the Cockroach

Cockroaches are oval, flattened, fast-running insects. Their body structure permits them to squeeze into very small cracks, which makes it extremely difficult to seal them off from harborages. Cockroaches have long hair-like antennae, a saddle-like plate (pronotum) that covers the thorax and projects forward over the head, and antennae-like structures called cerci that extend from the rear of their abdomens. The adults of most species are fully winged. The outer pair of wings are leathery in appearance and the hind wings are membranous and folded under the forewings.

Cockroaches go through gradual metamorphosis with three stages in the life cycle: egg (a number of eggs are laid in a capsule-like case called the ootheca), nymphs (the young pass through several molts but basically look like adults except they are smaller and have no wings) and adult. Occasionally a white cockroach will be seen. This is merely one that has recently molted and has yet to regain its normal color. Most species are nocturnal and seek protective cover in the daytime.

In general, cockroaches prefer an environment that is warm, dark, and humid. The four major factors that influence areas where they will inhabit are: temperature, moisture, food supply and amount of light. The areas where cockroaches will be found will vary among species depending on environmental preferences resulting from a mixture of these four factors and population pressure.

German Cockroach
Blattella germanica

The German cockroach is the most common species encountered indoors in Arkansas. This species can complete one generation in approximately one-fourth to one-half the time of other species. Thus, it is no wonder that the German cockroach is found in such great abundance and can infest or reinfest a structure in a comparatively short period of time.

Once a female German cockroach contacts a chemical and dies, the eggs in the case (oothecae) protruding from her abdomen generally die also. Other domestic species may deposit egg cases on surfaces not reached by a chemical. Consequently, the eggs may continue to hatch over a 30- to 60-day period. The residual activity of some chemicals is not long enough to kill the later hatching nymphs, and retreatment is sometimes needed to insure adequate control.

The German cockroach prefers areas of warmth and high humidity, which are generally found in the kitchen and bathroom. Consequently, monitoring for and thorough treatment of these areas is needed for control of German cockroaches. Typical resting places for German cockroaches include under and behind large appliances, under sinks, and in the cracks and crevices of drawers and cupboards. Severe infestations of German cockroaches will frequently result in a scattered infestation throughout a building. German cockroaches are capable of rapidly adjusting to different conditions and situations. Occasionally they may be found behind ceiling trim, between ceiling voids, and other similar locations, especially in commercial buildings.

Figure 2-1. German cockroach, *Blattella germanica*

Figure 2-2 and Figure 2-3. As with many species of cockroaches, female German cockroaches lay their eggs into a capsule called an ootheca. German cockroach females carry these egg cases throughout most of the incubation period.

Characteristics:

- Adults are pale brown to tan and approximately 1/2 inch long.
- Adults are fully winged and have two dark stripes that run lengthwise on the pronotum (the shield-like plate behind the head).
- This species has the highest reproductive potential (number of eggs laid and shortest life cycle) of the house-infesting cockroaches.
- Females carry egg cases (oothecae) protruding from their abdomen until eggs are ready to hatch. Females produce about four to eight capsules in their lifetime. Each capsule contains 30 to 48 eggs that hatch in about 28 days at room temperature.
- Females live an average of 250 days.
- German cockroaches will generally be found close to moisture and food (e.g., kitchens and other food areas, restrooms, and around plumbing fixtures). Check such items as cracks and crevices, under tops of tables, behind sinks, in cabinets, the motor compartments of refrigerators, soft drink and other equipment, underneath kitchen equipment, in switch and fuse boxes and other areas where conditions are favorable.
- When they are found scattered throughout non-food areas of building, it is usually due to very heavy population pressure.

Figure 2-4. Brown-banded cockroach, *Supella longipalpa*

Brown-banded Cockroach

Supella longipalpis (*S. supellectilium*)

The brown-banded cockroach prefers warm but frequently drier locations than the German cockroach. Brown-banded cockroaches tend to be found in higher locations, such as behind wall decorations or bureaus, and behind plates covering electrical switches and plugs. This cockroach may be found in any room, and an infestation is frequently spread throughout the structure. In addition, the female carries the egg case only a short time making control of this species difficult if a building is not thoroughly treated. In Arkansas, this species is not nearly as common as German cockroach.

- Brown-banded cockroaches vary from light tan to glossy dark brown in color. The adults are slightly smaller than German cockroaches and have two light yellow or cream-colored transverse bands at the base of the wings.
- Egg capsules (oothecae) are usually deposited or glued to surfaces in dark areas such as cabinets, chairs, couches, drawers, and in higher areas of the building. Females produce about 14 capsules in their lifetime. Each capsule contains about 18 eggs that hatch in 50 to 75 days, depending on temperature.
- Females live an average of 200 days.
- Brown-banded cockroaches tend to scatter throughout buildings, preferring temperatures of 80 degrees F or slightly higher. These cockroaches are more often found in homes, apartments, hotels, hospital rooms, stores or restaurants. Infestation frequently results from shipments of furniture, luggage or other animals.

Figure 2-5. American cockroach, *Periplaneta americana*

American Cockroach

Periplaneta americana

The American and Oriental cockroaches may be found outdoors during the warmer months of the year, as well as indoors. The Oriental cockroach prefers cool, damp situations and is usually found near the floor level of basements. They are also frequently found in abandoned cesspools, storm drains, water meter boxes and crawlspaces under buildings.

The American cockroach prefers warmer temperatures and moist areas, but occasionally they may be found in some fairly dry sites. They are likely to be found in upper levels of basements, alleyways and sewer systems. American cockroaches are often found in food handling establishments and industrial plants. Occasionally, control of Oriental and American cockroaches may require treatment of outdoor areas, underneath crawlspaces and indoor areas.

Characteristics:

- American cockroaches are the largest species found in buildings in Arkansas. Adults average about 1 1/2 inches in length, are reddish-brown in color and have a light yellow or tan band around the edge of the pronotum.
- The oothecae are usually dropped near food sources. Females may produce an egg capsule per week until 15 to 90 are produced. Each capsule contains from 14 to 16 eggs. Eggs hatch in 50 to 55 days at room temperature.
- Females live an average of 450 days.
- Nymphs and adults are commonly found in dark, moist areas. Common habitats include sewers, basements, boiler rooms, steam tunnels, storm gutters, machine rooms, around manholes, under buildings and around plumbing fixtures. Occasionally they will be around garbage containers or dumps in alleyways. They are more commonly pests in hospitals, zoos and in institutional or industrial buildings than in homes.

Oriental Cockroach
Blatta orientalis

Characteristics:

- Adults are approximately one inch long and dark brown to black in color. This species is often referred to as the "waterbug."
- Females have small wing pads, while males have wings that cover about three-fourths of their abdomen. Neither sex can fly.
- Females drop egg cases in warm, sheltered areas near a food supply. Females produce an average of eight egg capsules, with each containing about 160 eggs. Under room conditions, eggs hatch in about 60 days.
- Females live an average of 180 days. Nymphs and adults have similar habits and are frequently found associated with decaying organic matter indoors and out. Oriental cockroaches are rather gregarious and "clusters" are generally found in moist, dark habitats. Common habitats include floor and storm drains, water meter boxes, under siding next to soil, around plumbing fixtures, crawl space areas underneath buildings, sewers, basements, around dumps, garbage containers, and compactors. Oriental cockroaches are seldom found high on walls, in high cupboards or in the upper floors of buildings.
- This species can live approximately 30 days without food if water is available, but die within two weeks without water.

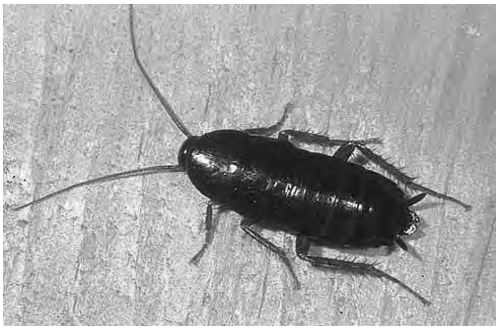


Figure 2-6. Oriental cockroach, *Blatta orientalis*

Wood Cockroaches
Parcoblatta spp.

Characteristics:

- The most common species in Arkansas is the Pennsylvania wood roach, *P. pennsylvania*. The adults are about one inch long and chestnut brown to black in color. The edge of the thorax and front half of the wing are margined with yellowish white.
- Males are fully winged and are strong fliers. The wings of females cover only one-third to two-thirds of the abdomen.
- Males are attracted to lights during the mating season, May and June, and to the lights around buildings. Occasionally, males will congregate around doors or windows or in gutters of buildings, especially when the building is near creeks and wooded areas.
- Nymphs and adults are usually found outdoors beneath loose bark, in woodpiles, stumps and in hollow trees. Females deposit their egg capsules loosely behind the bark of dead trees, fallen logs or stumps.
- They are normally only nuisance/annoyance pests. Females rarely deposit egg capsules in homes or other buildings. The possibility of continuing infestation is highly unlikely. Inside treatment is occasionally needed. Replacing outside incandescent lights with yellow lamps frequently helps reduce wood cockroach problems.

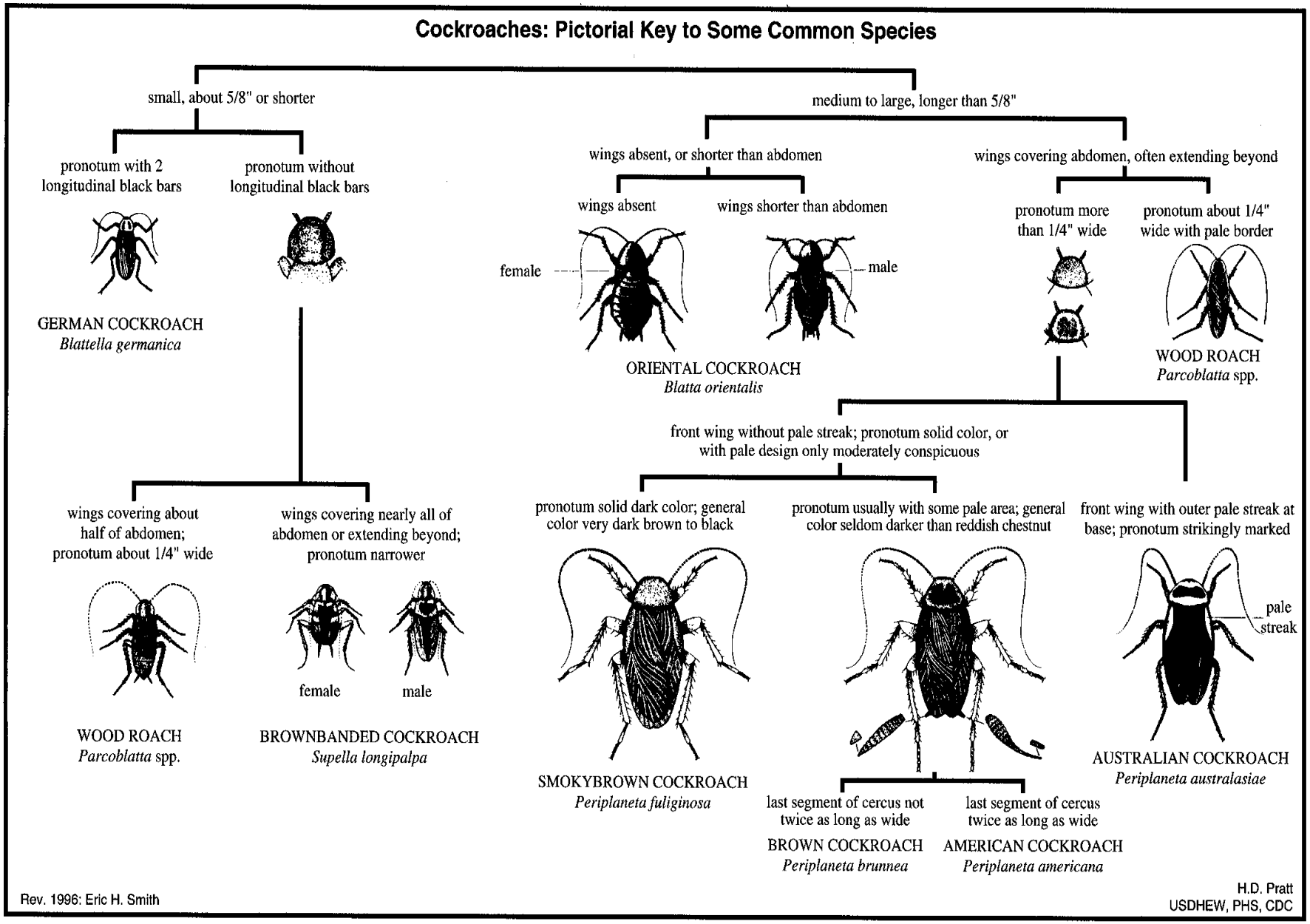


Figure 2-7a. Cockroaches: pictorial key to some common species

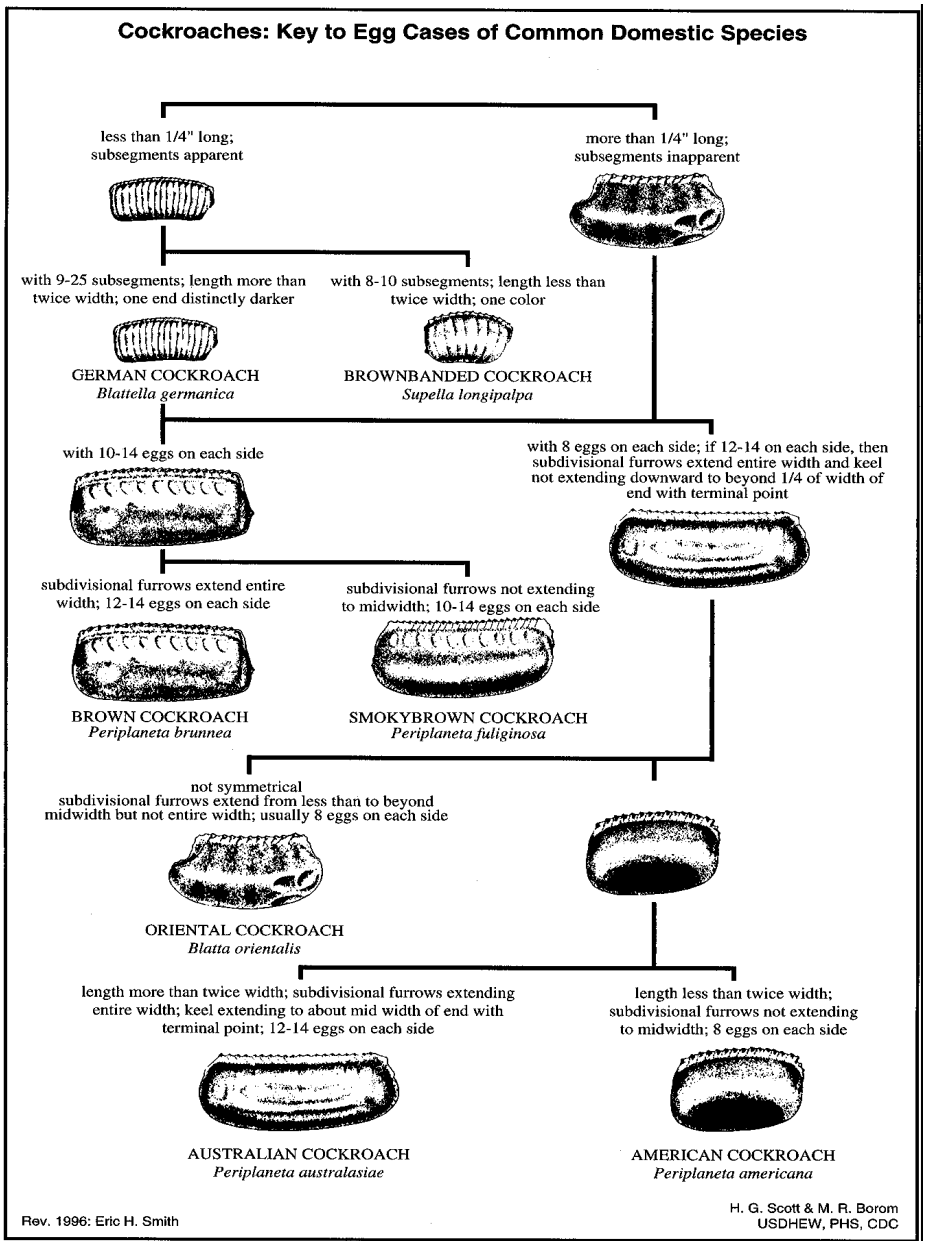


Figure 2-7b. Cockroach Egg Cases: pictorial key of the common domestic cockroach species

Management Guidelines for Cockroaches

The control of cockroaches requires a great deal of care and planning on the part of the pest control operator. Successful management depends on identifying the species involved and then selecting methods of control that are effective against these species. Because life cycles and habits vary with the species, knowledge of these factors is important in finding their hiding places and establishing a control program.

Careful inspection is necessary to find their hiding places and then to treat them thoroughly. Nighttime surveys are useful because cockroaches are nocturnal (active at night). Use a flashlight and search in cracks, under counters, around water heaters and in other dark location. Look for live and dead cockroaches, cast skins, egg capsules and droppings – all of which aid in identification.

Good sanitation is as important as the use of insecticides. The pest control operator should work very closely with the customer to see that all

possible sources of food supply are removed. Cleanliness and good housekeeping are very important. Do not leave food exposed. Keep garbage in closed containers and check dog and cat foods because roaches can live on these alone. Eliminate dripping faucets, leaking water pipes and other sources of moisture. Keep sewer openings screened. Incoming merchandise, especially groceries and drink cartons, should be inspected for cockroaches and egg capsules. Unnecessary boxes and other trash should be discarded. Exclusion of roaches by such methods as equipment design, good screening, tight-fitting doors and by filling cracks and crevices is important in a program of prevention and control.

In spite of sanitation, cockroaches do become established in some locations. Before and during treatment, a thorough inspection with a flashlight should be made to locate infestation sites. A flushing should be made to locate infestation sites. A flushing agent may be useful. Often, where no previous control has occurred, the initial treatment consists of what is commonly known as a "cleanup" or "clean-out." That is, sprays and/or dusts are applied in a very thorough treatment. There is an immediate reduction in the number of roaches, but usually they are not totally eliminated. There are several reasons for this. The egg cases may not have been affected by the treatment and more roaches emerge one to several weeks later. It may not be possible to kill every roach in heavily infested premises. For these reasons, some pest control operators apply a "follow-up" treatment one to several weeks after the "clean-out." Often, it is general practice to apply control measures at monthly or shorter intervals to keep the infestations at a minimum and to prevent further reinfestation. Less insecticide and time is required in these "follow-up" trips; consequently, the cost of treatment is much less than that for a "clean-out."

Control chemicals may be oil base sprays, water emulsion sprays, dusts and, for some species, baits. Choice of chemical frequently is dependent on the situation requiring treatment. Dusts may not be appropriate where they would be unsightly or cause contamination problems. On porous surfaces, oils will penetrate deeply and leave less surface residue than will a water emulsion. Most of the time a residual chemical is preferred for roach control, but in some instances, it may be necessary or desirable to use a contact spray. Common residual sprays include oil-based or water emulsion sprays. These sprays should be applied to cockroach harborages with emphasis on cracks and crevices, and minimizing treatment of exposed surfaces. When it is necessary to treat exposed surfaces, the application should be made with a low-pressure spray. Avoid runoff or puddling. Excess spray should be wiped up immediately to avoid staining or damaging certain materials. Other precautions include:

- Do not apply oil-based insecticides near open flames, to tile floors or on plants.
- Do not use water-based sprays near electrical outlets.
- Remove pets and cover aquariums before spraying and allow treated surfaces to dry before dishes, foods, cooking utensils or other items are placed on them. These items should be covered or removed when it is necessary to spray near them.

No matter what type of insecticide is used, insecticides placed in or near regular hiding places will give better control than those placed where roaches will only walk over them occasionally.

Contact or space sprays are used to knock down and flush cockroaches from their hiding places. These insecticides irritate the insects, causing a very rapid response. For this reason, they are useful as a **flushing agent** to bring the insects out of their hiding places. Space treatments used alone do not penetrate cracks and crevices well enough to provide effective control, but cockroaches on exposed surfaces can be killed with space treatments.

Dusts are useful for placing insecticides into cracks and crevices, under large appliances and other harborage areas. Light applications are more effective than heavy applications that may repel insects. Dusts generally provide longer residual control than sprays except under conditions of excessive moisture that can make them ineffective. Silica aerogels also may be used alone or in combination with insecticides.

Baits are generally long lasting and can be applied to sensitive areas that cannot be effectively treated with sprays or dusts. Baits often include an attractant and/or a food source, in addition to an insecticide. To be effective, baits need to be used in small amounts placed very close together because of competition from other food sources; baits only work if the cockroach eats it. Baits can be effective when used in conjunction with other methods and treatments. Heat can cause bait formulations to run and drip.

When using a baiting method, it is important to nutritionally stress the roach population by practicing good sanitation. A larger portion of the cockroach population will find and consume bait if there is, less alternative food available. It is also important to recognize the nutrients that cockroaches need (such as protein and fat around a stove, or carbohydrates in a pantry) to help with choosing baits and where to place them. For example, a cockroach infestation in a pantry may not have a water source readily available; therefore, gel bait may be more practical. Alternately, an infestation of cockroaches under a sink, with a stove or fryer located some distance away, might allow the use of bait with higher levels of protein.

Equipment

Several types of application equipment may be used for roach control; however, the hand-operated compressed air sprayer is most frequently used. To apply a residual spray over a general surface, a fan or cone nozzle should be used. Be certain the insecticide is cleared for spot treatments if the application is being made in a food-handling establishment such as a grocery store or restaurant. Generally, it is most desirable and often specified by the label to force the insecticide into cracks and crevices where roaches hide. This is done with a fine pin stream nozzle or a nozzle equipped with an extension tube that aims the insecticide as directly into the crack as far as possible so that it will penetrate deeply. A sprayer pressure from 15 to 40 pounds is adequate for this method of treatment.

Dusters most commonly used in roach control are small rubber bulb or bellows-type hand dusters. They are designed so small amounts of dust can be placed in narrow cracks and crevices.

It is important to remember to only use formulations of insecticides registered by EPA for cockroach control and for the particular site or location where control is needed. Most labels of insecticides registered for roach control have very specific instructions for their use in food and non-food handling locations. Read and follow these instructions to the letter. Consult your pesticide dealer, Cooperative Extension Service or Arkansas State Plant Board for insecticides labeled for cockroach control.

Cockroaches may avoid certain deposits of residual insecticides. For this reason, it is important to use materials that do not repel them; otherwise you must have thorough coverage to ensure that the cockroaches will contact treated areas. Cockroach populations may develop resistance to the insecticides. Populations of cockroaches migrating in from another area may already be resistant to insecticides that were used against them elsewhere. Methods that may help to reduce resistance problems include:

1. Use of alternate, nonchemical control methods such as biological control and good sanitation.
2. Lowering the frequency of insecticide application.
3. Alternating the types of active ingredient and formulation.
4. Using insecticides that do not repel cockroaches.

Sometimes cross-resistance develops in cockroach populations. This is a condition where the resistance to one type or class of insecticide makes the insect resistant to one or more other types or classes of insecticides.

Monitor and Evaluate

After a cockroach control program begins, evaluate the effectiveness of the methods. Use traps or visual inspections to help determine if treatment is necessary. If populations persist, reevaluate the situation. Look for other sources of infestations, make sure that all possible entryways are blocked, be certain that food and water sources are eliminated as much as possible and continue sealing and eliminating hiding places. Repeat insecticide applications if necessary. However, if insecticides appear to be less effective, resistance may be occurring. Overuse of insecticides and indiscriminate application may cause resistance.

If cockroach populations are controlled, continue monitoring with baited traps to check for reinfestation. Maintain sanitation and exclusion techniques to avoid encouraging a new infestation. If severe reinfestation continues, consider having the areas modified or remodeled to reduce the amount of suitable cockroach habitat.

Ants

Ants are among the most prevalent pests in households. They are also found in restaurants, hospitals, offices, warehouses and other buildings where they find food and water. Most ants can bite with their pincer-like jaws (few actually do and some have venomous stings). However, they are annoying pests primarily because they appear in large numbers and may nest in wall voids or other part of structures. Ants contaminate and destroy some agricultural products and stored foods. Certain species stain or cause feeding damage to textiles. On outdoor plants, ants protect and care for honeydew-producing insects (aphids, soft scales and mealybugs), which may interfere with the natural biological control of these pests. In nature, ants may perform beneficial functions by preying on certain species of insect pests and aerating soils.

Ants belong to the insect order Hymenoptera and are close relatives of bees and wasps. Ants, like many other hymenopterans, are social insects with duties divided among different types, or castes, of adult individuals. Queens conduct the reproductive functions of a colony, laying eggs and participating in feeding and grooming. Sterile female workers gather food, feed, and care for the larvae, build tunnels, and defend the colony. Workers are not always the same size in a given species as in the case of the black carpenter ant. Larger workers with well-developed mandibles are called soldiers. Males do not participate in colony activities; their only apparent purpose is to mate with the queens, after which the male dies. The male is generally winged and keeps its wings until death. Males are usually larger than workers, but smaller than the female reproductives. Few in number, males are fed and cared for by the workers.

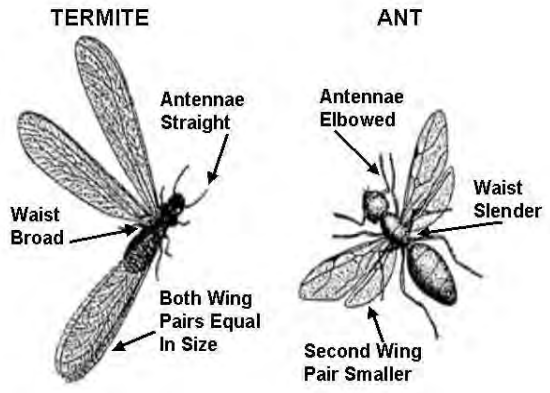


Figure 2-8a. Basic differences between ants and termites

Ants have narrow or pinched waists; that is, their body is very thin where the abdomen and thorax join. In addition, their antennae are elbowed, meaning that each antennae looks like an arm bent at the elbow. Fully winged adult ants are often confused with swarmer termites, but they can readily be differentiated based on the following:

1. Ants have elbowed antennae and termites have straight, beadlike antennae.
2. Ants have pinched waist lines, while the bodies of termites are virtually the same width from end to end (or termites have broad waists).
3. The front wings of ants are longer than their rear wings, while both pairs of wings of termites are about the same length.

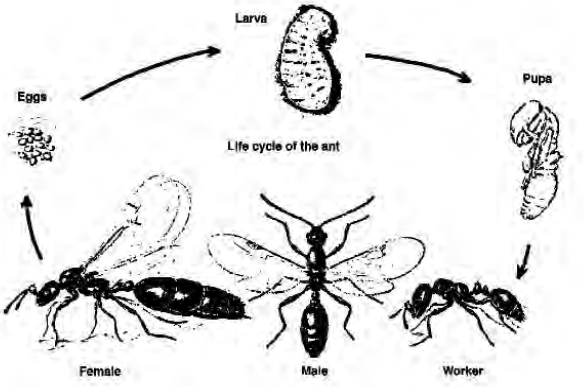


Figure 2-8b. Life cycle of the ant

Ants have complete metamorphosis; thus the development stages are egg, larva, pupa and adult. The eggs are extremely small and vary in shape according to species. Upon hatching a soft, legless larva is produced. After feeding and passing through several molts, the larvae pupate. The pupa resembles the adult, but it is soft, white and does not move or feed. The adult may require a few days to attain complete maturity after emerging from the pupal stage. Six to eight weeks or more are required for development from egg to the adult stage depending on the species and climatic conditions.

Ants require water for drinking and will travel some distance for it if necessary. This is frequently the reason for finding ants in kitchens or bathrooms of residences or commercial buildings.

Ants that invade homes and buildings include the **Argentine, odorous house, pharaoh, thief,** and **carpenter**. Other species such as

imported fire ants may be occasional indoor pests. Harvester, cornfield, pyramid and other species of ants nest outdoors but also occasionally invade structures.

Acrobat Ants
Crematogaster spp.

Description, Development and Habits

Acrobat ants tend aphids and mealybugs for honeydew and also feed on other insects. They usually establish their colonies in or under rotting logs and stumps in nature and sometimes live in abandoned carpenter ant galleries if the wood is damp enough. They can also engrave their own small galleries in wet roof boards, house siding, porch rafters, pillars, sill plates or any part of a structure where the wood does not completely dry out. Like Pavement ants, Acrobat ant colonies occasionally dump their refuse. It consists of tiny wood shavings like those of the Carpenter ant. The difference between Acrobat ant and Carpenter ant shavings is that those of the Acrobat ant are smaller and always dark stained from fungus. Acrobat ants may feed inside in kitchens.

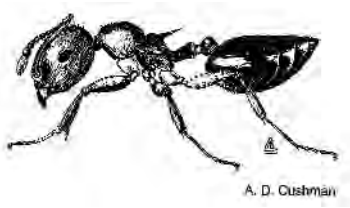


Figure 2-8c. Acrobat ant

Worker ants measure around 1/8 inch in length. The ant has two nodes; it is shiny-brown to nearly-black in color. The workers appear to have their abdomens attached ***upside down***: flat on top, "bellied" below and pointed at the tip. When excited they point their abdomens up or even over their heads, hence, their name. Acrobat ants are common over most of the United States. There are many species.

When an infestation of Acrobat ants is suspected, look where structural wood has been subjected to water leaks. Habitat alteration is the best means for controlling an infestation. This can be accomplished by removing and replacing damaged wood, altering grade and redirecting downspouts that pitch water toward structural wood and cleaning or replacing gutters. Trim overhanging tree limbs that keep wood from drying, and move logs, stumps, leaves and grass clippings away from structures. Habitat alteration is the best long-term solution, but the use of contact sprays may be needed for persistent problems.

Argentine Ant
Iridomyrmex humilis

The Argentine ant forages in restaurant, grocery stores, offices, schools, warehouses and any other location where suitable food and water are available. It is a persistent pest and is difficult to control once it has established a colony inside or near a building. This ant is not a native species, but it was introduced into the United States around 1890.

Description, Development and Habits

The adult worker is about 1/8 inch long and is light to dark brown. Queens are lighter colored and are 3/16 to 1/4 inch long; several hundred queens may live in a single, large colony. Argentine ants usually nest in the soil and are often next to buildings or along sidewalks. They also construct nests under boards and plants and sometimes under buildings. They occasionally make nests in wall voids or in soil of houseplants if conditions are satisfactory. When foraging, thousands of workers form long trails from the nest to the food location. Ants can be seen traveling in both directions along these trails. Workers all share food with each other and with the colony's queens.

Figure 2-8d. Argentine ant

The queens lay tiny white eggs throughout the year. The maximum production, between 20 and 30 eggs per day per queen, occurs during warm months. The average incubation period is 28 days under favorable weather conditions. After hatching, larvae remain in the nest and are fed, groomed and protected by adult workers. The larval stage lasts approximately 31 days and pupation takes about two weeks. During warm weather, colonies usually break up into smaller groups and migrate closer to

food supplies. In the winter, they again aggregate into larger colonies. Mating most often takes place in the nest rather than on a mating flight. Queens can live as long as 15 years.

Inside a building, the Argentine ant feeds on sugars, syrups, honey, fruit juice and meat. Outdoors it is attracted to the sweet, sticky secretions called honeydew produced by soft scales and aphids. It also feeds on dead insects, other arthropods and decomposing tissues from dead animals. This diversified diet aids colony survival and success because there is almost always some food available. The Argentine ant's high reproductive potential (a result of the large number of queens in each colony) and the ability of a colony to rapidly adapt and settle into nest sites in a great variety of buildings and natural locations also contribute to this species' success. New colonies can be set up quickly and grow rapidly in size because queens mate in the nest and participate in the feeding and grooming of larvae. The Argentine ant has no important natural enemies.

Big Headed Ant
Pheidole spp.

This ant is found in and around homes, but it is primarily a seed feeder nesting in the soil. This genus is remarkable for the large heads of the soldiers. In some species of Pheidole, the huge heads of the soldiers are removed by the workers before the winter season. Apparently this is because it is easier to breed new soldiers than feed old ones. These ants may enter homes contaminating a wide variety of foods. In the wild they feed on live and dead insects, seeds and aphid honeydew.

Description, Development and Habits

Depending upon the species, small big headed ant workers are 1/16 to 1/10 inch in length. Large workers (soldiers) are 1/10 to 1/7 inch in length. The antennae are 12 segmented with a distinct three segmented club. The head of the major worker is very large in comparison to the size of the body. The body color is light to dark brown.

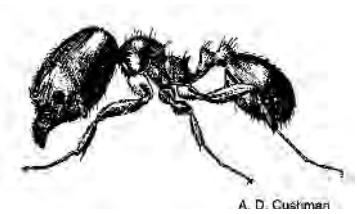


Figure 2-9a. Big headed ant

Carpenter Ant
Camponotus spp.

This ant is frequently found in decaying logs in woodlands and because of their habit of dwelling in and excavating wood they are given the common name of "carpenter ants." They are very often pests in lawns as well as in homes. Structures can be threatened by damage from carpenter ants. These long-legged swift moving ants rank among the largest ants.

Description

Workers vary greatly in size from 1/6 to 1/3 inch with the queens ranging from 1/2 to 1 inch in length. Most ants are dark brown to black in color but some are red and black. The workers of this group do not sting, but are capable of inflicting a painful bite.

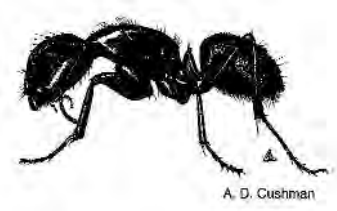


Figure 2-9b. Carpenter ant

Cornfield Ant
Lasius alienus

The nests of these ants occur very commonly in fields. In and around the home they may be found between bricks in the wall, beneath rocks, in cracks in the pavement, in lawns, etc. Their nests may become extended to form a group of mounds. This ant will enter the home in search of sweets and becomes a problem in the home. They will also feed on the honeydew of other insects and are predacious on other insects. This ant is moderate in size (1/10 inch), brownish in color and is often found in association with the aphids common on the roots of corn.

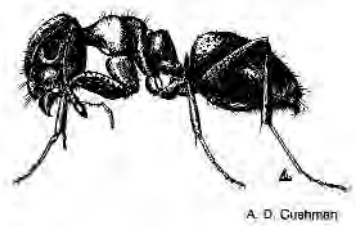


Figure 2-9c. Cornfield ant

Crazy Ant
Paratrechina longicornis

This ant has a very slender body about 1/8 inch long; it has only one node and is glossy dark-brown, nearly black in color. It can be found in some scattered locations in Arkansas.

Figure 2-9d. Crazy ant

The Crazy ant is unique in appearance. The antennae and hind legs are each as long as the body. These ants do not trail each other, but large numbers follow pathways along foundation walls, pavement, and such. The Crazy ant gets its name from its rapid, jerky gait; in large numbers it runs so rapidly, it is impossible to focus on a single individual. Some colonies become immense and have been observed both outside and inside throughout an apartment complex. Populations fluctuate during the summer rebounding after wet weather, declining during dry weather. Crazy ants accept broad menus of food including insects and especially enjoy concentrations of house fly larvae, garbage and kitchen scraps.

Colonies have been repeatedly introduced to the United States with plants from South America, Puerto Rico and the Philippines. Colonies exist outside in the southern United States and can overwinter in buildings in the northern portion of its range.

Crazy ant infestations quickly call attention to themselves by their activity. When outside, inspect manholes, crawlspaces, window wells and refuse piles. Inside, inspect garbage rooms and kitchens as well as apartments. Give special attention to entry through doors and windows on ground floors. Investigate connections such as pipe chases between kitchens and garbage rooms. Habitat alteration is recommended for management of this pest. Practice the highest standard of sanitation in homes, commercial food services, and food processing establishments. Always leave food areas clean after work. Practice garbage schedule control (dump before dark) and maintain clean garbage rooms, garbage cans and dumpsters and their surroundings. Caulk and tighten-up around doors and windows and low wall penetrations. When using pesticides for control, granular formulations around foundations and dumpsters can be applied and watered in to give initial population suppression. Residual pesticides alone, or fogs in garbage rooms and food areas that are not also cleaned up, will not control large populations. Crazy ants usually don't respond well to bait insecticides. Crack and crevice application must be thorough. Spot treatment around doors reinforce other control and management efforts. Dusts in infested manholes and other protected voids kill large numbers.

Large Crazy ant infestations need to be followed and treated until the population is controlled. Monitor areas that support high populations such as garbage rooms, etc.

Southern Fire Ant
Solenopsis xyloni

This fire ant is a native species occurring throughout most of the South. However, it is now absent from many areas where it was once abundant because of pressure from the imported fire ant species.

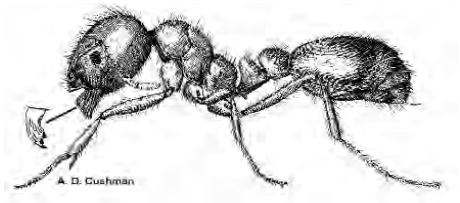


Figure 2-10a. Southern fire ant

This species is an outdoor ant that nests in the ground. The ground nests are as large as those of the imported species, but are more flattened. Nests of imported fire ant species are more cone-like in shape. However, this varies considerably with soil type and moisture conditions.

Description, Development and Habits

The workers are 1/10 to 1/5 inch in length. The head is not greatly enlarged and the pedicel is two segmented. The first segment of the pedicel its narrow in profile with a sharp, blade-like summit. The thorax of the worker is heavily sculptured with many ridges. Color varies from red to black. Mandibles have three teeth in contrast to the imported fire ant, which has four teeth.

Importance

This fire ant is an important predator of all ants. As such, it should not be eliminated without good reason, especially since it is not as aggressive as imported fire ants. Typically, once it is eliminated from an area, the imported fire ant species moves into the vacated niche. However, the sting of the "native" fire ant is painful. Enough stings may result in the death of young birds and poultry. Due to the lack of an excessively aggressively nature, they are less likely to cause stinging problems.

Figure 2-10b. Red imported fire ant

Imported Fire Ant
Solenopsis richteri and *Solenopsis invicta*

There are two species of imported fire ants. The black imported fire ant, *Solenopsis richteri*, entered the U.S. in 1918 or earlier. This ant now occupies only a small area in Alabama, northern Mississippi, and eastern Arkansas. The red imported fire ant, *Solenopsis invicta*, did not enter the U.S. until about 1940 and has spread rapidly. This ant presently infests many southern states, including the lower two thirds of Arkansas.

Description, Development and Habits

Imported fire ants are 1/8 to 1/4 inch in length and reddish brown to black. They are social insects and that live in colonies up to 200,000 individuals. Fire ant colonies are made up of a queen ant, winged males and females (virgin queens), workers and brood (eggs, larvae and pupae).

Since it is not necessary or desirable to treat for native fire ants, it is important to know the difference between the native fire ant and the red imported fire ant. The head of the imported fire ant large worker is not wider than the abdomen, whereas the head of the native fire ant large worker is wider than the abdomen. Imported fire ants nests are rounded and conical; nests of native fire ants are irregular in shape. However, in sandy soil, the conical mounds of imported fire ants do not maintain their shape.

Biology

The winged reproductives mainly leave the fire ant colony on mating flights in late spring and summer, although swarming may occur at any time of the year. The ants mate during flight, and the females land to begin a new colony. Most of the females fly or are blown less than one mile from the nest, but some may travel a distance of 12 miles or more. Fire ant nests are normally prevalent in open, sunny areas. Pastures and other farmlands, roadsides and home yards are often infested.

In heavy soils, each mature colony of imported fire ants can build a mound that is sometimes as much as 2 feet tall and 3 feet in diameter. In many heavily infested areas, there are as many as 50 mature colonies per acre. Infestations of 20 to 30 colonies per acre are common. In freshly invaded areas, there may be several hundred small, new nests per acre. Imported fire ants achieve their greatest density in high maintenance areas such as lawns, parks, roadsides, pastures and areas disturbed by flooding, draining, mowing or plowing.

Importance

The imported fire ant is a small, aggressive ant that causes damage difficult to measure in dollars. In landscaped areas, its large mounds are unsightly. Its painful, burning sting results in pustules that may take up to ten days to heal. If broken, the pustule may become infected. Some people have allergic reactions to fire ant stings. Such a reaction may cause seizure or heart attack. A few individuals have died as a result of allergic responses to fire ant stings, but this is rare. More people die from bee stings than fire ant stings.

Fire ant mounds in yards, playgrounds and recreational areas are a hazard to children and pets. In southern states, imported fire ants are often found in electrical boxes and air conditioning units around homes and businesses.

Harvester Ants
Pogonomyrmex spp.

The harvester ant is most commonly found in parking lots, sidewalks, lawns and landscaped areas. It is an occasional invader of buildings. This ant has the worst sting of any ant in Arkansas and will usually attack when disturbed.

Description and Habits

These ants are relatively large in size, from 1/5 to 1/2 inch long, and vary in color from red to dark brown. Males are black and red. These ants have a brush of long hairs on the underside on the head. Vegetation is often destroyed from the large areas and their chief food is seeds and grains of various kinds. Nest openings are characterized by a fan-shaped mound.

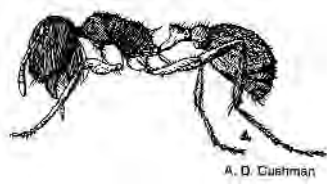


Figure 2-11a. Harvester ant

Little Black Ant
Monomorium minimum

Nests are found beneath rocks, in lawns or in areas free of vegetation. Nests in the ground may be identified by their appearance (very small craters of fine soil). This ant may also establish its nests in the woodwork or masonry of buildings.

Description, Development and Habits

This ant differs from the pharaoh ant in that it is jet black in color and 1/16 inch (1.5 to 2 mm) long. The antennae are twelve segmented with a three segmented club.

Their natural food is honeydew, but sweets are their preferred foods; therefore, they may occur in homes. The colonies are large and each contains a number of queens.

Figure 2-11b. Little black ant

Odorous House Ant
Tapinoma sessile

The odorous house ant gets its name from the foul, musty odor emitted when it is crushed. Like other ant pests, the odorous house ant sometimes invades houses and other buildings in great numbers.

Description, Development and Habits

The worker is approximately 1/8 inch (3 mm) long and has a brownish to black body. It is slightly longer and broader than Argentine ants. Nests are made outdoors in sandy soils, pastures, wooded areas, under stones and logs, in trees and tree stumps, and occasionally in bird and mammal nests. In homes it will nest in the walls, sills, under foundations, around water pipes and water heaters or beneath the floor. This ant is largely a sweet-eater and becomes a household pest especially after rains which wash away much of the honeydew secretions left by aphids and other insects. In locations where the Argentine ant is also a pest, the odorous house ant is usually driven off or out competed for food.

Figure 2-11c. Odorous house ant

Pavement Ant
Tetramorium caespitum

The pavement ant is found in New England, occasionally the Middle West, and in California. The pavement ant is of interest since it invades homes for food. This ant forages in the home throughout the year, but is observed in greatest numbers during summer. The nests are outdoors under stones, along edges of curbing and in cracks in the pavement, especially when the latter is next to the lawn. Sometimes small craters surround the nest openings. During the winter, the ants often nest in the home in a crevice near a heat source such as a radiator. Although the workers can bite and sting, they are not as aggressive or painful as the fire ants.

Description, Development and Habits

Pavement ant workers are 1/10 to 1/8 inch long. The antennae are twelve-segmented with a three-segmented club. The head and thorax are highly sculptured with numerous parallel ridges running lengthwise. There is a second pair of spines on the posterior dorsum of the thorax. The body is light brown to black, but the appendages are lighter. Hairs are thickly distributed over the entire body.

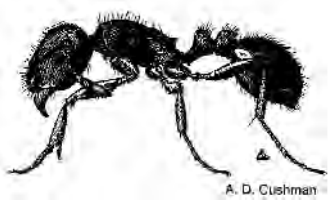


Figure 2-12. Pavement ant

Pharaoh Ant
Monomorium pharaonis

Pharaoh ants are particularly troublesome pests because of their small size and the fact that they feed on a variety of foods, including syrups, fruit juices, jellies, cakes, greases and even shoe polish. They are greatly feared as pests in hospitals because they have been known to enter the open wounds of patients and also carry bacteria.

Description, Development and Habits

The workers of this ant are 1/16 to 1/12 inch long and vary in color from yellow to red. They can be distinguished from the similar-appearing thief ant by the three segments in its antennal club; the thief ant has two. Use a hand lens to examine the ant's antennae to assist in your identification. Queens produce four to twelve eggs per day throughout the year and are most productive during warmer seasons. Under average weather conditions, eggs hatch after seven days. The larval stage lasts 18 days, followed by a three-day prepupal period and a nine-day pupation. Queens live approximately 39 weeks. Their diet includes sweets and fatty foods, although fats are preferred. Workers also feed on live and dead insects. Food is carried back to the nest for queens and larvae.

Figure 2-13. Pharaoh ant

Pharaoh ants enter buildings through cracks and other openings. They can also be transported into buildings on packages, supplies and furnishings. These ants nest in buildings, preferring warm places such as hot water pipes and heating systems. They colonize in wall voids, behind baseboards, between layers of flooring and under furniture. They also build nests in odd places such as in linens, appliances and paper products. Pharaoh ants travel great distances from nest sites to food and do not always follow the same path. This makes it difficult to find their nests.

Pyramid Ant
Dorymyrmex pyramicus

These ants invade homes and become pests in the garden. They occur from North American to Argentina.

Description and Habits

They feed on honeydew but are also predacious, feeding on other ants and insects. The workers are generally 1/8 inch long with a definite pyramid or tooth on the thorax. These ants are a uniform black color or have a reddish tint on the head and abdomen. These ants construct small cone-shaped nests that often are found on the side of harvester ant nests.

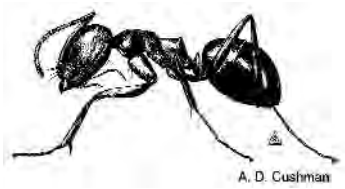


Figure 2-14. Pyramid ant

Thief Ant
Solenopsis molesta

Thief ants are pests in homes and other buildings. Their name is derived from the habit of building nests near colonies of other ant species and stealing food from them. They also kill and eat larvae of larger ants. Thief ants are small, light-colored ants that may be difficult to see, especially in some parts of buildings or poorly lighted areas. They are attracted to greasy foods, cheese and animal feces. Being one of our most important house infesting ants, it is common around the kitchen sink and cupboards. Because of their size, they can get into almost any type of container where food is stored. Their omnivorous feeding habits make it possible for them to transmit disease organisms to food items. They are persistent and difficult to control once they have invaded a building.

Description, Development and Habits

This is one of the smallest ants; workers are about 1/32 inch long and are yellowish in color. This species resembles pharaoh ants, but individuals are smaller. They have a two-segmented antennal club whereas the pharaoh's antennal club is three-segmented. Workers are capable of inflicting stings if they are disturbed, although they are not very aggressive.

Figure 2-15. Thief ant

Eggs incubate for about 22 days. The larval stage lasts 21 or more days, the prepupal period 2 to 11 days and pupation 20 days. When thief ants nest outside, their colonies are usually found under rocks or boards near nests of other ant species. They build small tunnels into the nests of larger ants, providing them access to food as well as the larvae of their host. Thief ants may also build nests in wall voids and other secure locations inside buildings.

General Management Guidelines for Ants

The best control of ants can be achieved if the nest can be located and treated. Since ants nest both indoors and outdoors, we will deal with each location separately. Specific ant control techniques for various species will be reviewed separately.

Indoor Ant Management

Certain species of ants are more likely to nest inside a home. These species include the thief ant, Pharaoh ant, and odorous ant. Control of these ants is more likely to be effective if the foraging workers can be traced to the nest. This may be difficult to do because the workers may be coming from under baseboards, behind a sink or under cabinets while the nest is in a wall or a false bottom of a cabinet some distance from where the ants are entering. Treatment only at the points of entry may be ineffective if they find alternate routes to food. Forcing an insecticide dust into all cracks and crevices for several feet on each side of where the ants are seen is a good practice. Sometimes drilling small holes into voids for treatment is helpful.

Treatment of baseboards, door moldings and other cracks along the length of the wall from which ants are seen entering with residual sprays may be helpful in control for all but Pharaoh ants. A small strip of floor adjacent to the wall should also be treated. This treatment should be applied on both sides of the wall whether it is an inside or outside wall. Treat cracks in the wall or at the top of the wall. The object of residual treatment is to completely surround the nest area so that ants leaving the nest will be forced to cross the insecticide barrier. This might be difficult to accomplish if the wall joins several other walls or if the nest is beneath the floor or if the colony is very large as are pharaoh ant colonies. It may be necessary to start the treatment a considerable distance away from the infested area and then work towards the nest. Baits may be useful, especially for Pharaoh ants, and several commercially prepared ones are available. Check with your chemical supplier for appropriately labeled baits. Many of the commercial baits are classified as weak baits and do not repel ants as the strong baits may do. The disadvantage with baits is that control may take several weeks. Baits must compete favorably with other food sources. Some commercial baits have a sugar base and others have an oil base (peanut oil is commonly used). The advantage of baits is that the ants take the pesticide back to the nest and feed it to the larvae and reproductives. Place baits along the trails ants travel (out of reach of children or pets). Do not contaminate food or surfaces that exposed food will contact and always follow directions on labels of insecticides used.

Outdoor Ant Management

These ants become pests by foraging inside for food. It is important to find their nest and to treat it heavily with residual sprays or dusts. If dusts are blown into the nest with force, they will generally be distributed throughout the nest. In the case of large nests, it may help to pour two to five gallons of water into the opening after dusting. Dry wettable powders can be sprinkled on the nest and washed in with a hose. With some mound-building species, it helps to break or scrape the mound before treatment. Besides treating the mounds, the walls through which the ants are entering should be given a barrier treatment with residual insecticides. Spray steps, pillars, vines, bushes, wires, etc., that can be used for entry. A soil barrier around the building

Table 2-1. Characteristics of Common Ants Found In Arkansas

Ant Name	Major Forage Locations	Nest Locations	Food Preference	Size of Workers (inches)	Sting	Unique ID Characteristics
Argentine	Inside where food and water are available	In soil near buildings and sidewalks	Sugars, syrups, honey, fruit juice & meat	1/8	No	
Big Headed	Inside or outside	In soil	Seeds, insects and aphid honeydew	1/16 to 1/7	No	Large headed soldiers
Carpenter	Mainly outside, but will invade structures	Decaying logs, lawns & structures	Plant & animal materials	1/4 to 1/2	Painful bite	Long-legged & swift moving
Cornfield	Corn fields	Most common in fields, but also around structures	Honeydew of other insects and sweets	1/10	No	Found in association with the aphids common on the roots of corn
Fire Ant (Native)	Outside	Outdoor in soil	Other ants & insects	1/10 to 1/5	Yes	Large flattened nest mounds; mandibles have three teeth
Harvester	Outside, occasionally inside	Landscaped areas, park lots, sidewalks	Seeds & grains	1/5 to 1/2	Yes	Mounds are fan shaped; have a brush of long hairs on underside of head
Little Black	Outside	Under rocks, in lawns, areas with no vegetation	Honeydew & sweets	1/16	No	Jet black in color
Odorous House	Outside, but can invade structures	Sandy soils, pastures, wooded areas, in trees	Honeydew & sweets	1/8	No	Emits foul, musty odor when crushed
Pavement	Inside	Outdoors under stones, cracks in pavement	Sweets	1/10 to 1/8	Yes	Head & thorax highly sculptured with many parallel ridges running lengthwise
Pharaoh	Inside	Buildings in warm places	Syrups, jellies, juices, greases	1/16 to 1/12	No	Differ from thief ant by three segments in its antennal club
Pyramid	Inside & outside	Near harvester ant nests	Honeydew & other insects	1/8	No	Have definite pyramid or tooth on the thorax
Fire Ant (Imported)	Outside	Open sunny areas outside	Other insects & seeds	1/8 to 1/4 (varies)	Yes	Nests are rounded & conical; mandibles have four teeth
Thief	Inside	Near other ant colonies to steal food	Greasy foods, cheeses & animal feces	1/32	Yes	Have two segments in antennal club

should also be treated. The previous descriptions of some of the more common ants and the field key (Fig. 2-16) will aid you in identification. All the ants found on the field key are not covered in the previous discussions, only the ones more commonly encountered by pest control operators.

Management Guidelines for Carpenter Ants

Effective control of these ants is dependent on finding the nest. When carpenter ants are found in a building, they can be nesting inside or outside the building and entering to forage for food. In some circumstances, an entire colony may migrate from one nesting site to another, so it is important to eliminate the nest outdoors as well as the one indoors.

A thorough inspection of the building and the grounds because more than one colony may be involved. The inspection should include an interview with residents or managers, inspection indoors, inspection outdoors and sound detection.

The interview with the residents and/or managers should be used to obtain information on where ants have been seen, where they are most prevalent, patterns of their movement and whether swarmers or sawdust-like material has been seen. Moisture problems in the building should be determined because carpenter ants strike in these areas.

The indoor inspection should concentrate on looking for areas of wood associated with high moisture. Critical areas include plugged drain gutters, poorly fitted or damaged siding and flashing, wood shingle roofs, hollow porch posts and columns and leaking doors and window frames. Look for wood in contact with soil and wood in crawlspaces or under dirt-filled slab porches.

The outdoor inspection should include checking for tree holes, damaged areas in trees and by timbers and firewood for signs of carpenter ant nests.

Sometimes carpenter ants will be found in a perfectly dry environment. Nests may be found in hollow veneer doors and small void areas such as the space between the top of a door casing and the ceiling. In many of these cases, the wood is not mined. The ants are merely using existing cavities.

When looking for a nest indoors, look for:

1. Piles of wood debris ejected from the colony. This debris has a shredded quality that looks somewhat like shavings found in pencil sharpeners. Sometimes this debris is deposited in the voids in the wall and is not visible.
2. "Windows" or small openings to the nest. "Windows" may not always be present since the ants may use existing cracks.
3. Ant activity. The ants frequently forage in the kitchen, pantries, etc., for food. Few ants are seen during the day, as they are more active at night.
4. Swarmers possibly trapped in spider webs.
5. Damaged timbers. The surface may appear solid, but by sounding, the damaged areas can be located.

Outdoor inspection includes a thorough inspection of the structure as well as the grounds. Carpenter ants commonly nest in trees and stumps and use branches and vines to travel. While they may nest in living trees, they are more commonly associated with knot holes, scars, dead areas, and crotch areas. Firewood is another possible nesting site. Look for areas outdoors where a moisture problem may exist or did exist.

Sound detection is sometimes useful in carpenter ant nest location. An active colony at times produces a distinct, dry rustling sound which may be heard from outside the nest. The sound is not related to chewing of wood. It is thought to be a means of communication and intensifies if the colony is disturbed. Sometimes it is very loud but generally it can only be heard when conditions are very still and outside noises are at a minimum.

Protection of structures from carpenter ants requires destruction of ants in all of the colonies that are both in and/or near the structure.

Indoor Carpenter Ant Management – The steps to be taken are two-fold:

1. Eliminate high moisture conditions to aid in carpenter ant control and to prevent future attacks.
2. Apply insecticides to nest and nest areas. Dusts are particularly effective in treating nest galleries. They may be used alone or

in conjunction with sprays. Spraying or dusting the infested area with residual insecticides without locating or treating the nest usually does not result in complete control. These ants do not respond to baits. The foraging workers may come into contact with the insecticide and die; however, some of the ants confine their activities inside the galleries of the nest and survive. The queen and developing larvae would not be affected. Individual carpenter ants can live over six months without feeding, so it becomes obvious that the galleries of the nest must be treated.

Residual insecticides are usually preferred, but sometimes volatile or contact insecticides may be useful in flushing out and killing the ants. Under favorable conditions, vapors may spread to penetrate inaccessible areas in a nest that cannot be treated directly and thereby aid in eradication of the colony. These insecticides need to be injected or flushed directly into the galleries.

Consult Extension Service personnel or chemical dealers for specific insecticide control suggestions. Follow the instructions on the label.

The insecticides should be applied so as to reach as much of the areas inhabited or traveled by the ants. The extent of the galleries should be determined to whatever degree is practical by careful inspection. Then it is often advisable to bore 1/4 inch (6.25 mm) or 3/8 inch (9.37 mm) holes at about 12 inch (30 cm) intervals in the infested timbers to intercept the cavities and galleries of the nest. Void areas may be drilled into in the same manner. The spray or dust is best applied by using a nozzle that will fit tightly into these holes. The sprayer or duster should be of a type that will force the insecticide into and through the different chambers. Care must be exercised when using liquid insecticides so that the fluid does not leak through and stain surfaces adjacent to the treated areas. The holes may then be sealed by hammering in dowels as plugs or small corks of appropriate size. Approaches and areas adjacent to the nest should also be thoroughly treated with residual insecticides.

When it is impossible to find the nest, a more general treatment of the premises is necessary. The outside of the foundation should be thoroughly sprayed with a residual insecticide as well as the base of trees, fences and shrubs. Baseboards and doorframes should be sprayed also. In basements or crawlspaces, the mudsill (board that lies on top of foundation) and any structural timbers between it and the subfloor should be sprayed so that a continuous film of insecticide is present. Unused attic areas should also be sprayed. Since many of the carpenter ants do not forage, it is very difficult to eliminate an entire colony with a bait.

Outdoor Carpenter Ant Management – Control outdoors is most successful if residual insecticides are applied directly in the nests. Water emulsions or wettable powders generally are preferred over oil solutions because of the toxicity of the oil carriers to vegetation.

Pharaoh Ant Management

Control of these ants may be very tricky because of one of the ants' behavior patterns known as "fractionating" or "satelliting." If an insecticide is sprayed nearby they will scurry about, pick up eggs, larvae and pupae, and split-up-fractionate into several smaller colonies. Residual treatments must surround the entire colony. To insure the entire colony is surrounded, the residual treatment should be applied first to areas known to be beyond the infestation and then work towards the center. These treatments are considered to be barriers and will likely need to be repeated unless the nest(s) are found and treated. Pharaoh ants can generally be most effectively controlled through a comprehensive baiting program. Refer to the general discussion on control of ants for more detail on barrier treatments and the use of baits for ant control.

Harvester Ant Management

Control of the harvester ant requires finding nests and physically destroying them or applying insecticides to openings. Destroy nests by digging them up with a shovel or using a mechanical cultivator. Once nests have been opened and exposed, thoroughly saturate the area with soapy water to stop survivors from rebuilding. Ants in disturbed mounds that can potentially hold water during the winter months (or melted snow) will often be killed out or have their colony greatly weakened by freezing and thawing activity. Removing food supplies is nearly impossible unless all seed-producing plants are eliminated in the area where the colony forages. When working around ant nests, take precautions to avoid being stung by workers. Harvester ant venom usually causes a painful reaction that has been known to persist for over 30 days.

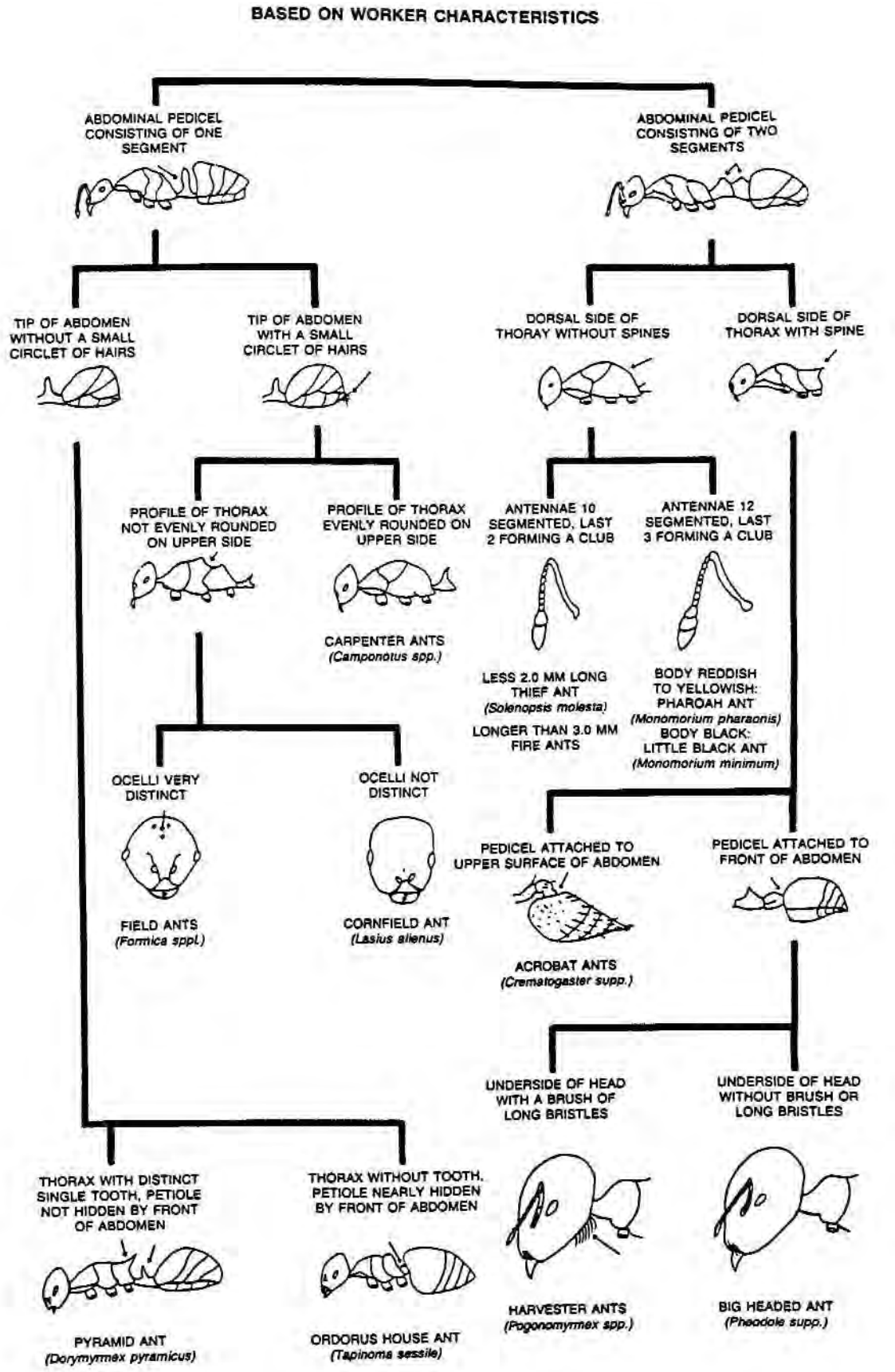


Figure 2-16. Field key to some common ants in Arkansas

Fire Ant Management

With some persistence, fire ants can be controlled by using the Two-Step Control Method. The two-step method is a simple approach that can control fire ants in heavily infested areas when conducted once or twice a year. The first step in this method is to broadcast a bait insecticide over the entire yard. The best times for applying baits are spring and fall, although baits can be applied any time during the warm season when ants are active.

The second step is to treat individual problem mounds with an approved mound drench, granule, aerosol, or dust insecticide. Individual mounds should be treated no sooner than three days after baits are applied. Treatments should be limited to mounds causing immediate problems, such as those found along building foundations or next to high-traffic areas such as sidewalks or play equipment. Be sure not to disturb mounds before treating.

Flies

The order Diptera (flies) is one of the largest and most diverse in the class Insecta. There are close to 17,000 species of flies in North America. Most of these flies are rarely encountered by man and are of little concern. A rather small group, referred to as domestic flies, have evolved to live in close association with man. These flies are typically found around or within structures and can become extremely annoying by their constant presence and ability to bite and transmit diseases. They also leave deposits of regurgitated food and excrement on walls, furniture, draperies, paintings and other belongings. Flies are also pests in outdoor eating areas, open-air markets and home yards.

Although there are several thousand species of flies, only a few are persistent pests in or around buildings. These include the **house fly; little house fly; green, blue, and black blow flies; stable fly; vinegar/fruit fly; false stable fly**; and **flesh flies**.

Fly Identification

It is extremely difficult to identify domestic flies in their egg or pupal stage. The larval stage may be used for identification, but this is frequently difficult. Table 2-2 provides a guide for identification of the common adult domestic flies.

Fly Biology

The life cycle of each species of the domestic flies is quite similar. The immature stages are found in moist, solid organic matter that is usually associated with man's activities. The female deposits small (approximately 1/25 inch long), white eggs in or upon the host material. The eggs typically hatch in a day or less and are extremely susceptible to desiccation (drying). The white, legless carrot-shaped larvae (maggots) may reach 1/2 to 3/4 inch in length. When preparing to pupate, the larvae move to drier areas of the host material.

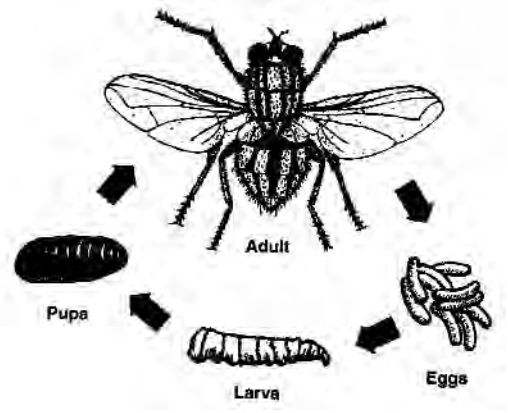


Figure 2-17. Life cycle of the fly

The pupa can be recognized by the hard, brown pupal case in which the larva transforms into an adult. Empty pupal cases may be found in the host material long after an infestation has ceased and are not necessarily a sign of an active infestation.

The development period of domestic flies is relatively short compared to other insects. The house fly, under favorable environmental conditions, is capable of developing from egg to adult in as few as 7 days. The cycle of the other domestic flies may be completed in as short as 8 to 18 days depending on the species. This short life cycle coupled with the ability of female flies to lay large numbers of eggs gives these pests tremendous reproductive potential. Under favorable conditions, large numbers can appear in a very short period. The specific biologies of domestic flies are presented in Table 2-2.

Management Guidelines

The basis for domestic fly control is the elimination or prevention of favorable habitats for fly production. If suitable habitats exist and environmental temperatures are favorable, a domestic fly problem will undoubtedly result. The use of insecticides is only secondary to sanitation and other

practices in fly control. Habitats where flies breed cannot effectively be reached or penetrated by insecticides. Insecticide treatment at locations other than the site of breeding and development is at best only a temporary means of control.

Some of the fly problems in urban areas and most of the problems in rural areas originate at sites other than in the immediate vicinity of homes, restaurants and similar structures. However, most flies live within a half mile of where they hatch. Rarely do large numbers of flies travel more than two miles. Nevertheless, if a large population exists around a structure, it is advisable to consider all possibilities of their origin.

Common agricultural areas where large fly populations may breed include chicken ranches, dairies, beef feed lots, hog ranches, horse stables and areas of crop production where manure is used or fruits and vegetables are culled.

Fly control in the urban areas follows the same principles as that in rural areas. That is, locate the breeding place or places of the population and eliminate the breeding site. The first step is to identify the pest species. In many instances this will limit the potential breeding localities. If large numbers of blue blow flies are present, the operator should first expect some animal carcasses in the vicinity. Once a breeding site has been eliminated, corrective steps should be taken to prevent a recurrence of the problem. Possible breeding areas for domestic flies are outlined in the following discussion.

1. Garbage cans and dumpsters are probably the single most important source of domestic fly production. Tight-fitting lids may be of some value. Also, twice a week garbage collection and a thorough cleaning of the cans/dumpsters are very helpful.
2. Grass clippings may be an important source of fly production if piles of grass are allowed to accumulate and decompose until the inner areas reach a slimy stage. If clipping piles are removed every other week, there should not be a fly problem.

Table 2-2. Identification of Adult Domestic Flies

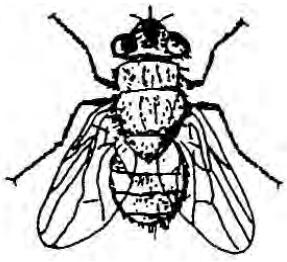
Species	Illustration	Identifying Characteristics
Black blow fly, *Phormia regina*		Shiny black or green and similar in size or slightly larger than house fly. Distinguished from green blow fly by presence of orange anterior spiracle.
Blue blow fly, *Eucalliphora* and *Calliphora* (several species)		Bicolored, the thorax gray with stripes and abdomen shiny blue. About size of green blowfly.
False stable fly, *Muscina stabulans*		Similar to house fly but can be distinguished by pale or reddish color on tip of scutellum and the fourth longitudinal vein only slightly curved upward near tip of wing.

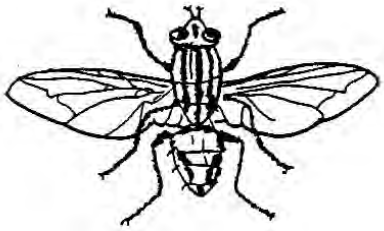
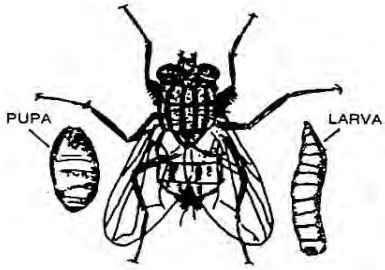
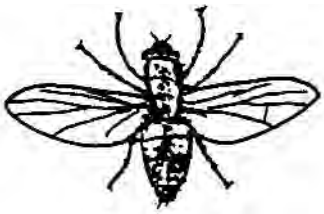
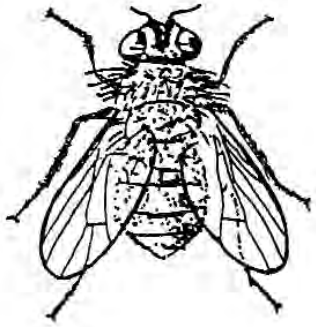
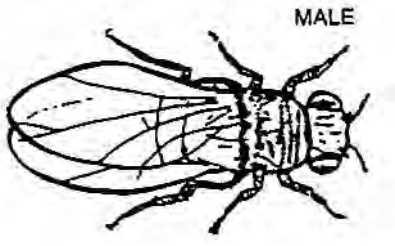
Table 2-2. Identification of Adult Domestic Flies (continued)		
Species	**Illustration**	**Identifying Characteristics**
Flesh flies (several genera)		Dull gray. Only 3 black stripes on thorax. Abdomen usually has a checkered pattern. Males of many species with red spot on tip of abdomen. This fly is generally larger than the house fly.
Green blow fly *Phaenicia* (2 species)		Shiny green or copper colored. Slightly larger and more robust than house fly.
House fly, *Musca domestica*		Dull gray with 4 stripes on thorax. Abdomen lighter color than thorax. Fourth longitudinal vein sharply angled. Body 1/4 inch in length.
Little house fly, *Fannia canicularls*		Males easily recognized by habit of hovering in protected places. Dull gray with abdominal segment next to thorax yellow. Similar in size to house fly, but less robust.
Stable fly, *Stomoxys calcitrans*		Similar in size to house fly, but has elongate blood sucking mouthparts. When at rest, body slightly angled rather than parallel to surface
Vinegar fly or Fruit fly *Drosophila* (several species)		Small (1/8 inch), yellowish brown. Typically found hovering around overly ripe or decaying fruits and vegetables.

Table 2-3. Biology of Domestic Flies			
Species	**Life Cycle**	**Adult Occurrence**	**Preferred Host Material**
House fly, *Musca domestica*	200-2000 eggs per female. Egg to adult in 7 to 45 days.	Prefer warm but not too hot weather. May occur year around but most abundant in September and October.	Larvae almost always occur in man-made sources; animal waste, culled fruits and vegetables are preferred.
Little house fly, *Fannia canicularis*	180-560 eggs per female. Egg to adult in 18 to 24 days.	Males typically hover in protected locations such as garages, porches and inside houses. Less abundant during summer and winter.	Larvae develop in almost all kinds of decaying organic matter. Chicken manure is usually the source of large infestations. Other types of manure also favored.
Green blow fly, *Phaenicia* (2 species)	3000 eggs per female. Egg to adult in 9 to 18 days.	Frequently most common flies in urban situation. Common during summer months.	Garbage cans common source during summer months. Dog droppings also preferred.
Blue blow fly, *Eucalliphora* and *Calliphora*	500-700 eggs per female. Egg to adult in 15 to 21 days.	Usually first flies to appear in the spring.	Decaying carcasses of birds and mammals. Also found in garbage dumps.
Black blow fly, *Phormia regina*	200-400 eggs per female. Egg to adult in 10 to 25 days.	Most common blow fly in wild areas. Active in relatively cool temperatures in spring and summer.	Decaying carcasses. Also lays eggs in open wounds of animals.
Stable fly, *Stomoxys calcitrans*	200-400 eggs per female. Egg to adult in 13 to 40 days.	Common around dairies. Occasionally attracted to and bite dogs in large enough numbers to be a problem.	Manure, especially when mixed with straw. Lawn clippings and animal feed waste also preferred.
Vinegar fly or Fruit fly, *Drosophila* (several species)	400-1000 eggs per female. Egg to adult in 8 to 11 days.	Most abundant around larval source and during fall, but can be present year around.	Larvae found in decaying fruits and vegetables. Garbage cans frequent source.
False stable fly, *Muscina stabulans*	140-220 eggs per female. Egg to adult in 15 to 30 days.	Most abundant in early spring prior to peak house fly emergence. Occur in many situations.	Manure and decaying plant waste such as culled fruit.
Flesh flies (several genera)	Female deposits 30 to 60 larvae instead of eggs. Eggs held in female until they hatch. Larvae to adult 8 to 18 days.	Year around, more common in warm months.	Garbage cans, manure (especially untrampled) animal carcasses including snails.
Moth fly, *Psychoda* (several species, also called sewer or drain flies)	30-100 eggs in irregular masses. Egg to adult in 8 to 24 days.	Most abundant around drains, sinks, bathtubs, water closets and sewage filter plants in the spring.	Sewage traps and wash basin drains.

Stinging and Biting Arthropods

Learning Objectives:

After completion of the study of Parasitic, Biting and Stinging Arthropods, the trainee should be able to:

- Identify common biting pests.
- Understand the biology and habits of biting pests.
- Cite integrated pest management options for biting pests.
- Understand the flea life cycle and how it contributes to flea problems.
- Discuss habitat alterations and why they are needed.
- Identify pesticide application methods for flea control.
- Understand when, how and why IGRs are helpful.
- Identify common urban stinging pests.
- Describe the differences of paper wasps, mud daubers, honeybees and carpenter bees.
- Given an urban stinging insect problem, describe integrated pest management procedures to suppress it.
- Describe the habitat and life cycles of common types of spiders that cause problems in urban areas.
- List the appearance or characteristics of harmful spiders.
- Understand pest management procedures for urban spider problems.

Arthropods that sting or bite to defend themselves or those that feed on the blood of people or domestic animals are serious and sometimes dangerous, pests. Stings or bites may result in localized painful itching and swelling which, if scratched, may even lead to a bacterial infection. Some arthropods transmit disease organisms through the wounds they cause. Some stinging and blood-feeding pests inject venoms capable of causing allergic reactions, which can be fatal. Biting or stinging arthropods include bees, wasps, spiders and scorpions in addition to ants, which were discussed in the previous chapter. Arthropods that feed on the blood of people and their pets include mosquitoes, some hemipterans (the true bugs), fleas, lice, ticks, midges and some mites. This chapter describes those stinging and biting pests that are most commonly found in or around homes or other buildings. The ones that may require pest control include **mosquitoes, bugs, fleas, bees, wasps, mites** and **spiders**. Medical or health professionals usually supervise control of **lice**. **Ticks** in structures are usually associated with pets and are best controlled in cooperation with a veterinarian. Some ticks transmit the organisms that cause Lyme disease and Rocky Mountain spotted fever; therefore, people suffering tick bites should seek medical attention.

Bees and Wasps

Bees and wasps, like ants, belong to the insect order Hymenoptera. They have complete metamorphosis. Adult bees and wasps are nectar feeders. Some adult wasps paralyze insects or spiders as food for their larvae and may consume small amounts of their prey's blood before stocking their nests. These insects are generally considered to be highly beneficial, although bees and wasps can be nuisances around buildings because they forage for food among flowers and around outdoor dining areas. They occasionally occur indoors. Sometimes bees or wasps become nuisances when they build their nests in wall voids, attics and other areas in or near buildings. Their nests can also be the source of carpet beetle infestations.

Bees and wasps are most notorious and feared because they defend themselves with a painful, venomous sting. The sting usually produces an intense local reaction accompanied by varying amounts of swelling. In some sensitive people, bee or wasp venoms evoke severe allergic reactions, known as anaphylaxis. After being stung a few times, allergic individuals may become hypersensitive to the venom's complex amino acids, proteins and enzymes. Occasionally, the reaction is so severe that a sensitized person may die shortly after a sting unless they receive drugs to counteract the allergic effects.

Honey Bees

The honey bee is a social insect that lives in colonies. There are three forms in the caste: queen, drone (male) and worker. The queen produces the

eggs for the colony. Honey bees may build nests close to a building or in walls, chimneys and attics of the building. If they build a nest in a building, their combs may melt allowing honey to seep through walls. In addition, other insects may infest the combs.

Weather often affects the temper of bees. They are more likely to sting on a cloudy or cool day, when they are unable to fly and forage for food.

The **Africanized honey bee** has not been found in Arkansas. The difference between African honey bees and European honey bees is one of degree. Both insects are honey bees; both display all the behaviors associated with honey bees. However, African bees sting, swarm and abscond much more than Europeans. Tests have demonstrated that African honey bees become alert to disturbances and prepare for colony defense much quicker than Europeans. Africans also sting at least ten times more than Europeans and continue to attack for longer periods of time and at much greater distances from the nest or hive.

Experience suggests that children and elderly people unable to escape when a stinging incident begins are most at risk when stung by a number of honey bees. In addition, small children (low body weight) and persons with high blood pressure and weak hearts are much more likely to succumb to large doses of bee venom. Most older children and adults can survive multiple stings with limited physiological harm.

Serious injury or death from a stinging incident (envenomation) can be prevented. Proper planning and preparation are necessary for agricultural workers, heavy machinery operators and others likely to encounter African bees. This precaution extends to homeowners as well. African honey bees nest in many places that Europeans would not. These include drainage culverts, highway underpasses and other places often exposed to the elements. Exposed nests for African honey bees are common, but are rarely constructed by Europeans.

The following precautions are recommended in areas inhabited by African honey bees:

1. Have a bee veil handy. Numerous stings can be tolerated on most parts of the body. Facial stings, however, can lead to headaches, fever and, in some cases, restricted breathing.
2. Be alert for possible shelter if a stinging attack begins. A vehicle or a building offers the best protection. Trying to lose the bees by hiding in foliage or walking among trees, often recommended for European honey bees, is futile.
3. For some people, one or two stings can result in an allergic reaction. An injection of epinephrine sold only by prescription in drug stores as either AnaKit® or Epipen®, is the only treatment for someone whose airway has been constricted by swelling or has developed anaphylactic shock. Usually, such a reaction is apparent within five minutes of being stung, and the epinephrine then must be used immediately. Before working where there is a likelihood of encountering African honey bees, consult with medical authorities for information on obtaining and using epinephrine and for precautions and hazards associated with its use.

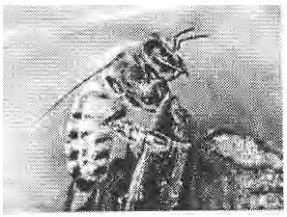


Figure 3-1. Honey bee

Carpenter Bees

These bees have a blue-black, almost metallic appearing abdomen. They build nests in wood by cutting tunnels that are approximately 1/2 inch in diameter. Just inside the entrance hole, their tunnels usually make a 90-degree turn and run with the grain of the wood. In buildings they commonly bore into roof rafters, gutter boards, beams, plates and patio wood fixtures. The female bees can sting but seldom do. Carpenter bees are distinguished from Bumble bees in that they do not have hair on their abdomen.

Bumble Bees

These are social insects that generally nest underground. They resemble carpenter bees, but they have yellow hairs on the top of the abdomen. They seldom become a problem to pest control specialists except when nests are established close to a sidewalk or near the foundation of a house or

building. Bumble bees use grass clippings for nesting material and prefer protected areas. Therefore, nests are not generally found in yards unless there are trash areas or outbuildings to nest under.

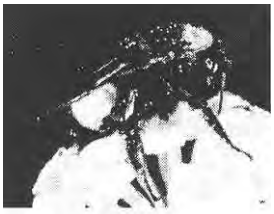


Figure 3-2. Bumble bee

Bee Management

Control of bees is directed at the nest. Protective clothing such as heavy coveralls, gloves, boots and veiled headwear is recommended to avoid getting stung. Because bees are beneficial, they should be removed rather than destroyed, if they are accessible. Most insecticide labels prohibit their use on honey bees; therefore, whenever possible, obtain the assistance of a beekeeper for removing a hive in or near a building because beekeepers have the skills and equipment necessary to do a safe and thorough job. To destroy a bee colony located in wall voids or inaccessible locations, use a fast-acting insecticide labeled for this purpose. Generally, dust formulations of insecticides are recommended for treatment of bees whose nests are in voids within walls. Treatment at dusk or dawn when bees are in the nests will often provide the best results. If possible, it is helpful to plug the entrance holes of carpenter bees after the nest has been dusted or sprayed. When treating honey bee nests in walls of buildings, it is not generally recommended to immediately plug the entrance hole, because they may find other exits in the building's interior. After the colony has been destroyed or removed, the entrances should be plugged.

Wasps

Wasps include those forms that are commonly known as mud daubers, yellow jackets, hornets, digger wasps, paper wasps, etc. Wasps have complete metamorphosis that includes the life stages of egg, larva, pupa and adult. The winged forms have four wings, although occasionally careful examination may be needed to see them, since in some species the front and hind wings on each side are frequently hooked together to function as a single wing.

Wasps are closely related to bees, but they differ from bees in that they feed their young primarily on animal matter, such as insects or meat particles, instead of honey and pollen.

The ovipositor or egg-laying structure is modified to form a stinging apparatus. A few people are extremely sensitive to the protein material injected by wasps and bees. These people may become extremely ill or die as a result of being stung only once. Fortunately, the percentage of human population affected in this manner is low, but similar consequences may result in a less sensitive person after several attacks from a number of insects.

Some wasps are referred to as "social" because they develop a family unit. The queen remains with her eggs and then feeds her young. The young, as they mature, take over the major duties of foraging for food, caring for the subsequent broods of young and building additions to the nests. Other species of wasps are referred to as "solitary" because they do not develop a family group. The female builds a cell or nest for each egg that she lays and provides each cell with food for the developing larva.

Social or Vespid Wasps

Many of the social wasps are referred to as paper wasps because they build their nests from paper, wood fibers or dead plants. The single comb wasps (*Polistes spp*.) build only one tier or layer of cells in their nests. Their nests are commonly seen under eaves of houses and beneath window ledges and porch roofs.

Figure 3-3a. Paper wasp

Hornet nests are large grayish-brown paper structures generally seen hanging in trees or bushes. Their nests resemble an inverted teardrop or a

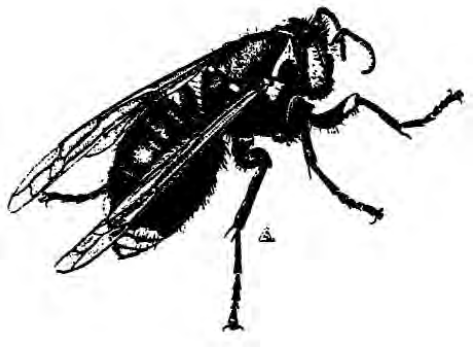


Figure 3-3b. Bald faced hornet

Figure 3-4. Bald faced hornet nest

Figure 3-5. Yellowjacket

"bloated football." Yellow jackets usually build nests underground. Frequently, the nests are in an abandoned rodent nests or similar cavities. As a general rule, hornets are the largest paper wasps, about 1 1/2 inches long; the single comb wasps are intermediate in size, about 1 inch; and yellow jackets are smallest, about 3/4 inch.

Solitary or Sphecid Wasps

Many different types of nests are built by the numerous species in this group. Mud-daubers construct their nests of mud, and digger wasps, such as the cicada killer, burrow in the ground to build their nests and can be found in flowerbeds around buildings. In most cases, the female carries out the work of building the nest and supplying the food for the larvae. The fertilized female constructs a cell and collects food, consisting of spiders, caterpillars or other insects, which she stings and places in the cell. She then lays an egg on the food and seals the cell. The larva has a supply of food on hand when it hatches.

Figure 3-6. Mud-dauber

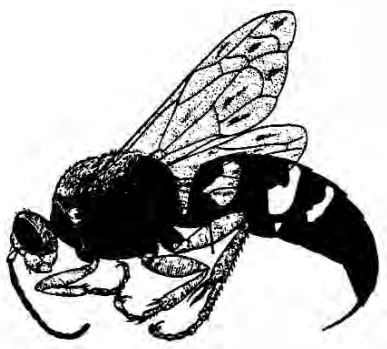


Figure 3-7. Cicada killer

Protective clothing, as recommended for bee control, should be worn to avoid getting stung. This equipment should be secured so the wasps cannot slip underneath. If possible, it is advisable to spray nests of wasps at night when the entire colony is in or on the nest. Spraying the openings to nests can usually control solitary wasps. Tearing down nests can eliminate most mud-daubers. Cells that have an external opening in them are empty. The opening was made by a newly emerged adult. Remove these cells because they contain food that may attract other household pests, such as carpet beetles.

Mosquitoes

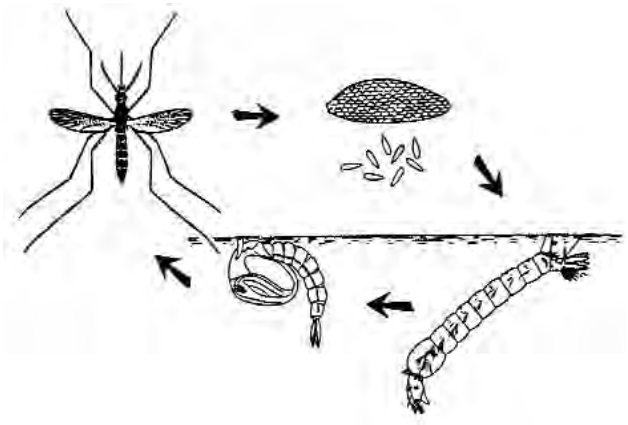


Figure 3-8. Mosquito life cycle

Mosquitoes are blood-feeding pests of people and animals. These insects belong to the order Diptera and are related to house flies, gnats and midges. Eggs of most mosquitoes are laid on the surface or near the edge of water. Mosquito larvae are aquatic, but they do not develop in rivers, lakes or ponds. They feed on algae, protozoans, and minute organic debris. Adult mosquitoes are winged and free living. Males do not bite, but females of most species require a blood meal before laying eggs, using the protein in blood for egg production. Mosquito bites usually result in red, swollen areas called welts that itch severely and may persist for several days. Some people develop allergic reactions to proteins injected by mosquitoes and become ill after being bitten. Some species of mosquitoes also vector microorganisms to people or animals. These microorganisms include those that cause malaria, yellow fever, encephalitis and dengue in humans, and heartworm in canines.

Mosquito Management

Mosquito control requires area-wide management of breeding sites and is usually the responsibility of public health agencies and mosquito-control districts. Control of mosquitoes in and around buildings depends on sanitation to eliminate breeding sites and exclusion to keep mosquitoes out of buildings.

To suppress mosquito populations or protect from the effects of mosquitoes, utilize any or all of the following strategies:

Source/Habitat Reduction

Drain any standing water and eliminate all objects or containers that hold water or could serve as a breeding site. These containers can be old tires, cans, bottles and dishes that contain water where mosquito larvae can develop. Look for blocked rain gutters as sources of standing water. Certain mosquitoes develop in water trapped in cavities of trees or basins formed by tree branches. Some species require only small quantities of water for short periods of time to develop. Livestock and pet water containers should be emptied and cleaned regularly to prevent mosquitoes from using these as breeding sites. Fish ponds and other bodies of water that cannot be drained periodically may be stocked with small mosquito fish (*Gambusia affinis*) or other top-feeding minnows that effectively control developing larvae. Exclude adult mosquitoes from buildings by using screens over doors, windows and other openings. If necessary, use appropriate insecticides to reduce biting females inside enclosed areas. These reductions will only be temporary unless steps are taken to exclude adult mosquitoes, eliminate breeding sites and destroy larvae.

Repellents/Avoidance

An insect repellent applied to skin or clothing reduces mosquito attacks on people who must spend time outdoors in areas where mosquitoes are a problem. For best results, read and follow label directions when using repellents. Remain indoors during peak biting times. If exposure to mosquitoes cannot be avoided, cover bare skin with clothing, avoid shaded grassy or wooded areas and wear light-colored clothing that is less attractive to mosquitoes.

Chemical Suppression

Use insecticides against mosquito adults and/or larvae to suppress the population level. Larvicides are applied to breeding sites and are used to control larvae and pupae. Adulticides are used to reduce the numbers of adult mosquitoes in a given area. Adulticides are applied through mist blowers and thermal fog generators or as ultra low-volume applications. Spray during the cool hours of the evening or early morning to prevent the insecticide from being dispersed by heat thermals and to contact adult mosquitoes when many are most active.

Fleas

Fleas are small, wingless insects that are flattened from side to side. Adults have piercing-sucking mouthparts and feed on the blood of warm-blooded animals. Fleas have complete metamorphosis. The eggs are usually dropped while the female is on the host. The eggs fall to the ground usually in the bedding or nest of their host. Depending on environmental conditions, it may take the eggs two days to several weeks to hatch. Larvae are slender, straw-colored, wormlike creatures. They are also legless and have chewing mouthparts. They feed on all types of organic debris including the feces of adult fleas that contain partially digested blood. The larval instars can be completed in a week or they may take several months.

When mature, the larvae spin cocoons that are covered with sand and organic debris and change into pupae. The pupal stage usually lasts from a week to a month, and unless stimulated by heat, physical pressure, substrate movement or carbon dioxide, the pre-emerged adult can remain quiescent in the cocoon for up to 140 days. Adults can resist starvation for extended periods both before and after feeding. However, a blood meal is required in order to produce eggs. With occasional feeding, adults of some species may survive for more than a year. Hot, dry conditions reduce flea development; while humid, rainy periods favor population buildups.

There are many different species of fleas that attack both animals and people. Cat and dog fleas are two common fleas found in and around homes. They attack either dogs or cats, and they both will bite humans. The cat flea is the most common flea in homes and on pets in Arkansas. Some species of fleas are important disease vectors, but possibly the worst effect experienced by humans is the irritation and occasional infections that result from scratching the bites of fleas.

Flea Management

The first step in flea control is to destroy or thoroughly wash the bedding of pets. Remove animal manure and debris from pens and yards. Then pet(s) should be treated by a veterinarian or by the owner. Vacuuming floors, carpeting and upholstered furniture and destroying the sweepings is as important as chemical controls. Vacuuming stimulates the pupae to emerge as adults. It is key to make sure the customer understands what is necessary to provide good control. Flea pupae and pre-emerged adults present a major problem in control and are the reasons fleas are observed after the application of insecticides and IGRs. Residual insecticides are important for knocking down the larvae and pre-emerged adults when they are stimulated to leave their cocoon, as well as stressing a strict vacuuming regimen to customers.

Use appropriately labeled insecticides on carpets, upholstered furniture, along baseboards, in tiled rooms and in other areas where fleas may be present. Dusts may be useful for placing insecticides deep into cracks and crevices or behind baseboards where insects may be. A space spray may be used to speed the knockdown of adult fleas in areas that cannot be broadcast sprayed. Follow the directions on the pesticide label for indoor use for flea control. It is also important to note that some insecticides and IGRs are not photostable or will degrade when exposed to sunlight.

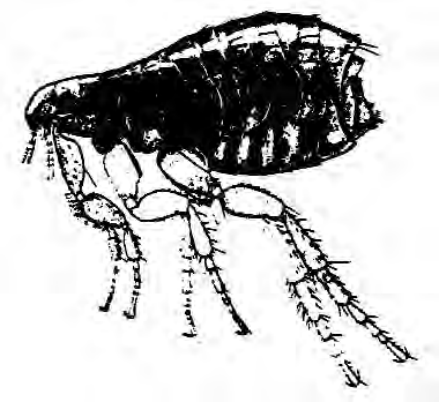


Figure 3-9. Adult flea

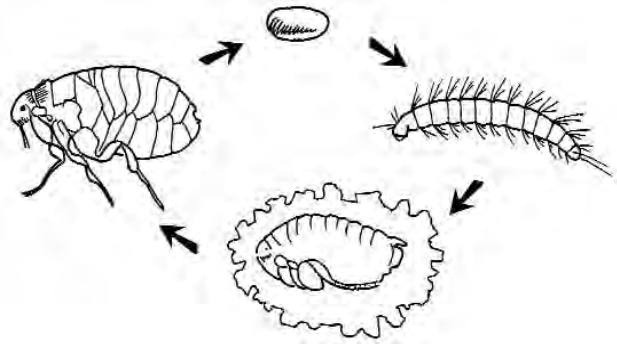


Figure 3-10. Fleas undergo complete metamorphosis through egg, larval, pupal and adult stages.

Table 3-1. Flea Management	
Technique	**Effect**
Pet Care	
Bathe pet on a regular basis (two to four times a month).	Kills some fleas. Dislodges loose hairs and skin debris that serves as food for larvae.
Groom pet daily, using fine-toothed flea comb. Good technique for cats.	Removes adult fleas and eggs. Removes loose hairs and skin debris.
Confine pet to single indoor sleeping area.	Keeps fleas confined to localized area where control efforts can be concentrated.
Spray pest and sleeping area with flea repellent. (Some repellents last 30 to 60 days; others must be applied as frequently as once each day.)	Helps to reduce number of fleas attacking pet.
Consult veterinarian for flea control product for use on pet. Many products cannot be used on cats.	Flea control products repel or kill fleas coming in contact with pet.
Interior Housekeeping	
Vacuum areas where pets sleep or spend time on a regular basis. (Clean at least twice per week and immediately dispose of vacuum cleaner bag.)	Removes eggs, larvae adult fleas, and skin debris. Also removes adult flea excrement and dried blood that provides food for larvae.
Keep pets out of carpeted areas and other hard-to-clean areas (such as closets).	Makes housekeeping functions that reduce fleas easier to perform.
Launder pet bedding on a weekly basis.	Kills eggs and larvae. Eliminates skin debris and hair.
Exterior Maintenance	
Mow grass, destroy weeds and trim shrubbery. Perform weekly as needed.	Exposes eggs and larvae to more sunlight and kills them.
Irrigate areas surrounding buildings on a regular basis.	Kills eggs and larvae.

If making treatments indoors, be certain aquariums are covered or removed, toys, clothes and other items on floors and furniture are picked up or not sprayed. Depending on the application procedure, advise the customer to keep children and pets away from treated surfaces until they are completely dry. If space treatments are made, tell the customer how long to keep persons and pets out of treated areas. Follow reentry directions on the label.

Quite often, indoor flea control will only be successful if outdoor and pet flea management are conducted at the same time. Otherwise, the pet will continually introduce fleas to the indoor environment.

Ticks

Adult ticks are leathery bodied, eight-legged arthropods that have two body regions and no antennae. Their mouthparts are adapted to penetrate and hold fast to the skin of the host and to withdraw blood. Ticks are divided into two main groups or families: **hard ticks** (family Ixodidae) and **soft ticks** (family Argasidae). Hard ticks are most commonly encountered by pest management professionals.

Hard Ticks

Hard ticks have a hard shield or plate on the dorsum (back) that covers the front one-third or so of unfed females, and the entire back of males and nymphs. Hard ticks have four stages in their life cycle: egg, larva (which has six legs), nymph, and adult. Their eggs are typically deposited in one large mass in debris on the ground. Hard ticks usually attach firmly to the host and may feed several hours to several days before dropping from the host.

Soft Ticks

Soft ticks do not have a plate or shield on their back. Instead their entire integument (skin) is leathery and often characteristically bumpy or granular in appearance. Soft ticks have five stages in their

life cycle: egg, larva (six legs), first nymph, second nymph and adult. The nymph and adults do not attach to the host. They take several blood meals before molting. Soft ticks generally are associated with the nest or dwelling place of their host.

Brown Dog Tick

The most commonly encountered tick by pest management professionals is the brown dog tick. It is a hard tick associated with domestic dogs, their kennels, runs and houses. However, they rarely bite humans and are not known to transmit human diseases. Occasionally, large populations build up in the home or in dog kennels. Typically, a dog will pick up a gravid (containing eggs) female in a dog kennel, veterinary office or another area where a population is already present.

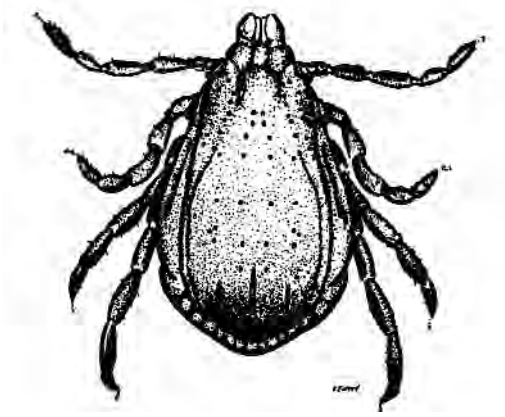


Figure 3-11a. Brown dog tick

The brown dog tick does not thrive well in outdoor situations, and unlike most hard ticks, this species spends all its life cycle in or near the living quarters of its host. In buildings, females usually lay eggs between boards, under plaster or carpeting, or in cracks and crevices. When larvae, nymphs or adults are not feeding on the dog, they hide in or around the pet's bedding or in cracks and crevices.

Under ideal conditions, the life cycle may be completed in about two months; however, under normal household conditions, there are three to four generations per year. Because larvae, nymphs and adults can live for extended periods without food, infestations can persist long after dogs leave the premises. Adults of this tick overwinter and usually become active in April, remaining so until October.

Importance of Ticks

When feeding, ticks make a small hole in the skin, attach themselves with a modification of one of the mouthparts which has teeth that curve backwards and insert barbed, piercing mouthparts to remove blood.

The presence of ticks is annoying to dogs and humans. Heavy, continuous infestations on dogs cause irritation and loss of vitality. Pulling ticks off the host may leave a running wound, which may become infected because of the ticks' type of attachment.

The brown dog tick is not a vector of human disease, but it is capable of transmitting canine piroplasmosis among dogs. The American dog tick may carry Rocky Mountain spotted fever, tularemia and other diseases from animals to people. Dogs are not affected by these diseases, but people have become infected by picking ticks from dogs. People living in areas where these ticks occur should inspect themselves several times a day. Early removal is important since disease organisms are not transferred until the tick has fed for several hours.

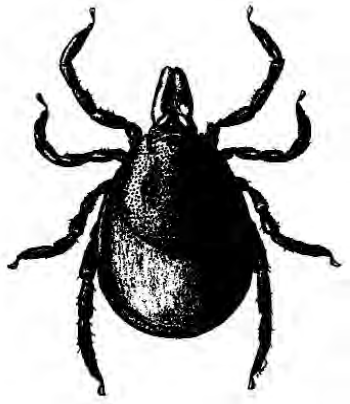


Figure 3-11b. Deer tick

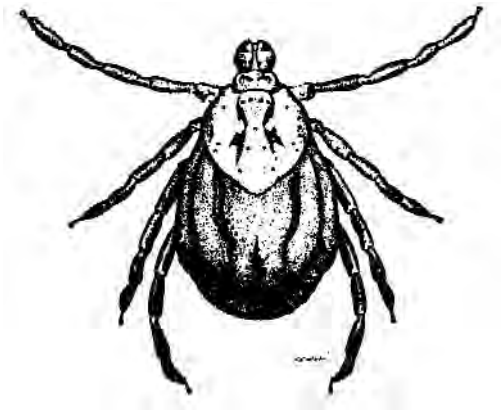


Figure 3-11c. American dog tick

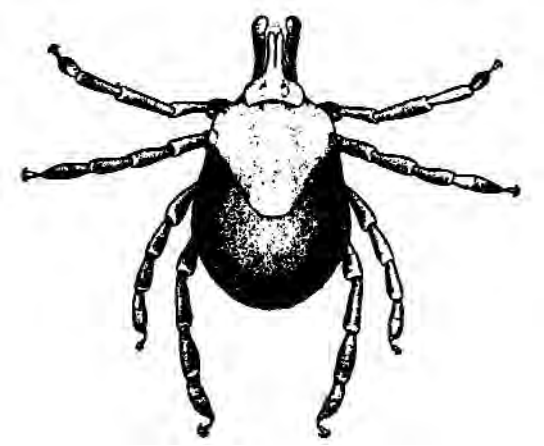


Figure 3-11d. Lone Star tick

Tick Management

Control measures against ticks depend upon the species of tick, the location of the infestation and the kinds of hosts involved. The brown dog tick is the only species likely to become continuously established in homes. For control of the brown dog tick, it is important that the dog be treated at the same time as the premises by a veterinarian or the owner. Infested bedding should be washed or disposed of. The area around the bed must be sprayed thoroughly with approved insecticides. All stages of the tick life cycle can be found in cracks and crevices, so getting the insecticide into these locations is important. During warm weather, outdoor areas frequented by the dog, such as dog yards, dog houses, and crawlspaces should be treated to reduce the chances of ticks being picked up and brought inside. Control of ticks outdoors involves changing the environment by removing low hanging limbs and dense shrubbery and by keeping tall weeds and grass mowed. It may also be necessary to spray shrubbery and areas bordering yards.

Lyme Disease

Symptoms of Lyme disease were described in Europe over 100 years ago. The disease was named in 1975 by a physician studying the symptoms of a group of children living around Old Lyme, Connecticut. This disease appears to be spreading throughout most of the country and has been detected in at least 43 states.

The disease, when left untreated, can involve the brain, the joints or the heart. It is caused by a corkscrew-shaped bacterium, or spirochete, similar to the one that causes syphilis. This spirochete is transmitted to people and animals through tick bites.

Preventing tick bites is the best way to keep from becoming infected with the spirochete. Anyone going into areas where ticks occur should do the following:

- Wear light-colored clothing including long pants, a long-sleeved shirt and a hat. Be sure to cover as much skin area as possible.
- To provide barriers to keep ticks from reaching the skin, pants should be tucked into boots or socks and shirts should be tucked into pants.
- Spray a repellent containing DEET on any exposed skin. Spray clothing with the repellent or a product registered for use against ticks, such as permethrin.
- If possible, stay on clear paths and avoid trail edges, brush and grassy areas.
- Examine all body areas for signs of ticks as soon as the clothing is removed. Shower immediately.

Bedbugs

Adult bedbugs are oval insects that are flattened and reddish brown in color. They are practically wingless (only small pads) and have piercing-sucking mouthparts. The sole food of bedbugs is the blood of humans, but they also suck blood from other warm-blooded animals. Bedbugs can live for nearly a year without a blood meal, but they cannot reproduce after long periods without food.

There are several species of bedbugs known to bite man. Most of these are associated with bats or are found in nests of birds. The common bedbug (human bedbug) is nocturnal in habit, taking blood meals at night and remaining hidden during the day. It can be found most frequently hiding in the seams and tufts of a mattress or in the cracks of bed frames. Other hiding places include behind wallpaper and wall decorations, in upholstered furniture, and in cracks and crevices of walls and window moldings.

The human bedbug has glands on its body that secrete an odorous oily material. A room heavily infested with this species will usually have a characteristic odor. After feeding this species will defecate. This material will appear as small black specks on mattresses, sheets or in the vicinity of their hiding places.

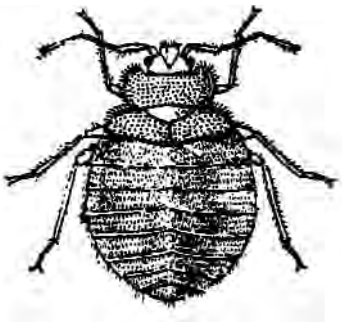


Figure 3-12. Bed bug

Bedbug Management

Control of bedbugs can generally be obtained by confining treatment to the sleeping quarters of the home. Steam cleaning of infested mattresses can effectively kill bed bugs living in seams and buttons. An approved insecticide must be applied to all hiding places to achieve control of bedbugs. Specifically, the mattresses and bed frames should be treated, as well as other furniture and cracks and crevices in the room. Spray the woodwork and all walls in the bedroom at least two feet above the floor. This treatment must be made with an approved chemical. Great care must be exercised around infants and sick or aged persons. Dry and cover mattresses completely before using. Spray again if there are any new signs of bed bugs. After two weeks, spray the bed, furniture and walls again.

Lice

Three different species of lice attack man. Head lice live mainly on the head and neck and cement their eggs, called nits, to the hairs close to the scalp. Body lice live mainly in clothing. Crab lice are found among pubic hairs but are also found on hairy areas of the chest, armpits and eyebrows of children. They attach their eggs to the hairs.

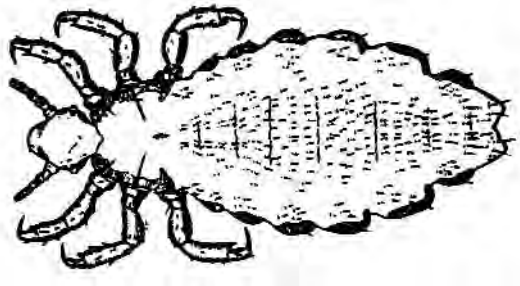


Figure 3-13. Head/body louse

Body lice transmit several diseases, especially when people live in overcrowded and unsanitary conditions, but head lice do not spread diseases. Epidemic or louse borne typhus and louse borne relapsing fever are important diseases carried by body lice, but are not a problem in the United States. Pediculosis is an important problem. This is a skin irritation resulting from severe louse infestations. Scratching the irritated area can result in streptococcal infections and in hardened, scarred and darkened skin. All three kinds of lice can cause pediculosis.

Head lice infestations are difficult to manage in schools since the children come in close contact, wear each other's clothes, use each other's combs, share cloak rooms, etc. If just a few children bring lice to a school, an epidemic can follow.

All three species have similar life cycles. Lice infesting man have three life stages – egg, nymph and adult. After hatching, nymphal lice take blood meals from their host and develop into sexually mature adults within eight days to four weeks. Nymphal lice removed from the host die within several days. Adult lice differ little from the nymphs except for the size and sexual maturity. Adult lice also take blood meals, and like the nymphal stages, possess leg parts that are particularly adapted to clinging to hair shafts of the host.

Avoid contact with infested persons, as well as the common use of articles of clothing, combs, pillows, etc. Infested clothing and bedding should be laundered in hot water or dry-cleaned. Body lice do not survive in clothing that is not worn for a month or more, and none of the louse species live for very long if not in close contact or on the body. Crab lice usually die within 24 hours; however, the others take longer. Lice are normally easily

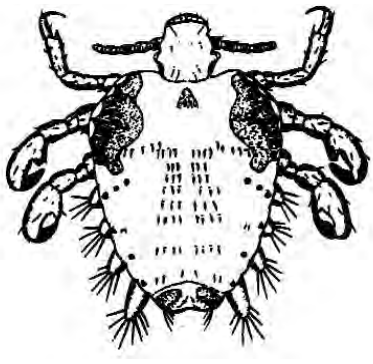


Figure 3-14. Crab louse

controlled on the body or head with medicated (insecticidal) soaps/shampoos. These products are available over-the-counter, so read and follow label instructions carefully.

Insecticides are not necessary to control head lice in classrooms or homes. Sanitation methods, such as vacuuming and washing contacted items in hot water, are sufficient. Head lice will die within 24 hours if not on a human head. Head lice are also not spread by pets.

Scorpions

Scorpions belong to the class Arachnida along with ticks, spiders and mites. Unlike other Arachnids, scorpions have an elongated, segmented abdomen that ends in a stinger. They have eight legs and a pair of pinchers. Most species of scorpions in the United States are nonlethal; however, there are two species mainly found in southern Arizona that are considered dangerous.

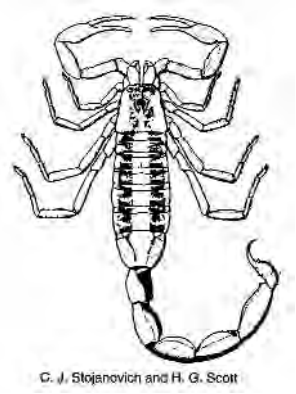


Figure 3-15. Scorpion

Like spiders and ticks, scorpions can withstand starvation for a long period, four to five months being common. Scorpions are nocturnal and feed on small spiders and soft-bodied insects. They have a long life cycle with three to five years being normal. Young scorpions are born alive and usually climb on the their mother's back where they remain until after their first molt.

Scorpions sting, but usually only when provoked or disturbed. Scorpion venom is a neurotoxin, but the dose injected usually is insufficient to prove fatal to an adult human. The site of the sting may be sore and swollen for some time. In houses, they are most commonly found in crawlspaces and attics but are also attracted to kitchens and bathrooms (or similar areas where moisture is available).

Scorpion Management

Elimination of harborage places, such as piles of wood and trash, is important. Spraying or dusting harborage areas in and around the house with insecticides with long residual action is useful for killing scorpions and for reducing supplies of prey upon which they feed. During dry weather, scorpions can be attracted and trapped by spreading moist burlap on the ground around infested areas. For specific recommendations for insecticides (sprays or dust), consult pesticide labels and/or consult with Extension personnel or your pesticide dealer.

Spiders

Although spiders are greatly feared by man, only a few species are dangerous. Most species are beneficial, feeding on insects and other arthropods. Many spiders are associated with moisture and are found in basements and crawlspaces. Others live in warm, dry places and can be found in air vents and in upper corners of rooms and in attics. Most species hide in cracks, in darkened areas or in silken retreats they have constructed.

Spiders are arachnids and have eight legs, but lack wings and antennae. Their bodies have two regions, cephalothorax (fused head and thorax) and abdomen. The two body regions are joined by a narrow connection that is called the pedicel. The two species of spiders that are considered dangerous to man are the black widow and the brown recluse.

Black Widow

The black widow spider, *Latrodectus mactans*, is found in every state in the United States. The male and female of the black widow are distinctly different in appearance. The female is shiny black with a bright red or orangish hourglass-shaped marking on the underside of her abdomen. Her bulbous abdomen may range from 1/4 to 1/2 inch in diameter. The male is much smaller and light colored and has light streaks on the abdomen. The venom of the black widow acts as a neurotoxin (affects the nervous system). The bite usually produces a stinging sensation, but the severity of a person's reaction may vary depending on the individual's age, area of the body where the bite occurred, depth of the bite, etc. Deaths from black widows have been recorded, so any victim should consult a physician for treatment.

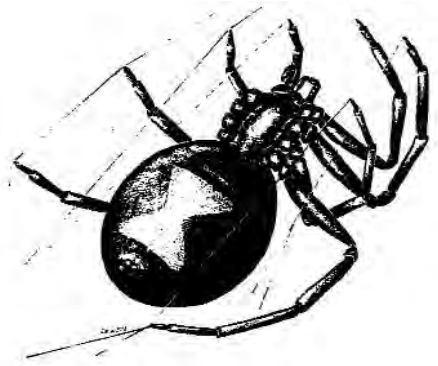


Figure 3-16. Black widow

Figure 3-17. Brown recluse

Brown Recluse

The brown recluse spider, *Loxosceles reclusa*, is also called the brown spider and the fiddle-back spider. It is a soft bodied, secretive spider that varies in color from yellowish-tan to dark brown. Distinguishing characteristics are the presence of three pairs of eyes arranged in a semicircle on the forepart of the cephalothorax and a violin-shaped dark marking immediately behind the eyes. The neck of the violin-shaped marking points back towards the abdomen. This spider may be found indoors in all types of buildings. When in homes they are frequently found in bathrooms, bedrooms, closets, garages, basements, under furniture and in attics.

Most bites occur when a person crushes the spider while putting on clothes or shoes that haven't been worn for some time or by rolling on the spider in bed while asleep. The victim may not be aware of being bitten for a few hours. A stinging sensation is usually followed by intense pain. A small blister usually rises, and the area around the bite becomes swollen. The tissue affected locally by the venom is killed and generally sloughs away. Healing takes place quite slowly and may take six to eight weeks. The end result is often a sunken scar that has been described as resembling a hole "scooped" from the body. Scars ranging from the size of a penny to a half-dollar have been reported.

Spider Management

Indoor control of spiders may involve nothing more than vacuuming up the spiders, their webs and egg sacs. Space treatment sprays are useful for clean outs and for eliminating outdoor species found indoors. Residual sprays can be applied to control spiders migrating indoors or those that are breeding indoors. Spray all areas where spiders have been found, giving particular attention to dark corners. Dusts may be useful in crawlspaces and on spiders migrating inside or to eliminate spiders on porches, under eaves and other areas. Clean up lumber piles, debris, boxes, etc., that harbor spiders.

Fabric Pests

Learning Objectives:

After completion of the study of Fabric Pests, the trainee should be able to:

- Identify common fabric pest groups.
- List the key features in the life cycle and habitat of some common fabric pests.
- Discuss inspection and prevention techniques for fabric pests.
- Discuss pest management procedures for fabric pests.

Fabric pests include insects that feed on natural fibers, synthetics and animal by-products. They damage clothing, upholstery, carpeting, draperies and other fabrics. Some of these pests are able to digest the animal protein – keratin – and feed on hides, furs, hair, feathers, animal horns and preserved insects and other museum specimens. Several fabric pests are also important stored-product pests (such as black carpet beetles, silverfish and firebrats).

Although these insects commonly feed on wool and other fabrics, these materials apparently do not contain adequate vitamins and amino acids (protein) to properly sustain their development. For this reason, fabric pests do not typically feed on "clean wool" but mainly attack wool and other fabrics contaminated by soil, food spills, urine or related nutrients. Contamination is frequently difficult to avoid and may be caused by perspiration, body oils and even air-borne microorganisms.

Four orders of insects have species considered to be fabric pests: Coleoptera (carpet beetles), Lepidoptera (clothes and webbing moths), Thysanura (silverfish and bristletails) and Orthoptera (crickets).

Carpet Beetles

Beetles make up the very large insect order known as Coleoptera. All beetles undergo complete metamorphosis and in the immature stage have several larval instars (stages between molts). They pass through a pupal stage before becoming adults. Adults are winged and many species are good fliers. Adult beetles are distinctive among adult insects because their front pair of wings are modified into hard body coverings known as elytra. When a beetle flies, "the elytra are raised to expose the hind wings. Elytra are shiny and brightly colored in some species of beetles; other species have a covering of fine hairs or scales.

Carpet beetles belong to the coleopteran family Dermestidae. Four species of carpet beetles cause serious damage to fabrics, carpets, furs, stored foods and preserved specimens. These insects are pests in warehouses, homes, museums and other locations where suitable food exists.

The carpet beetles can be identified in either the larval or adult stage. Adult carpet beetles can generally be separated by body shape, coloration, and the presence or absence of a cleft at the rear of the forewings. The larvae are characterized by body shape and the arrangement of hairs and tufts of hairs on the body. Diagnostic characteristics of the larval and adult stages of the carpet beetles are presented below:

Furniture Carpet Beetle, Varied Carpet Beetle and Common Carpet Beetle

These three beetles belong in the same genus (*Anthrenus*) and are similar enough in appearance and habits that they can be considered together. The **Anthrenus** carpet beetles feed on the same type of materials as the black carpet beetle. They are omnivorous and feed on many types of plant and animal matter. Adult carpet beetles commonly feed outdoors on pollen and enter the home to lay eggs in the spring and summer months. The feeding behavior of the *Anthrenus* species is distinctly different than that of the black carpet beetle. None of these three beetles burrow in their food material. As a result, they are more frequently encountered as surface feeders. A heavy infestation will show many larvae feeding in close proximity to each other on the surface, but feeding deeply enough to penetrate woolen fabric and other materials.

Black Carpet Beetle, *Attagenus megatoma*

Adults distinctly oval, dark brown to black, about 1/6 inch long. Larvae carrot-shaped with long tail bristles. Shiny brown to black.

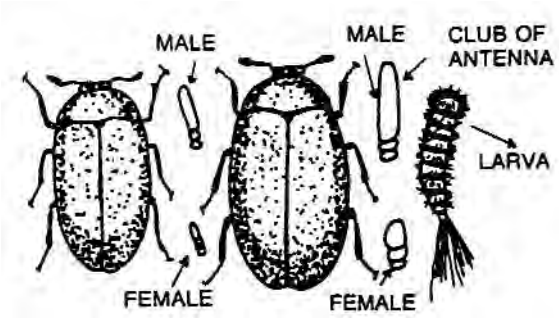


Figure 4-1. Black carpet beetle, *Attagenus megatoma*

Varied Carpet Beetle *Anthrenus verbasci*

Adults slightly oval shaped and mottled with white, brownish and yellowish scales. No cleft at tip of wings. Larval body wedge-shaped with rear broader than head. Three tufts of hair on either side of rear end.

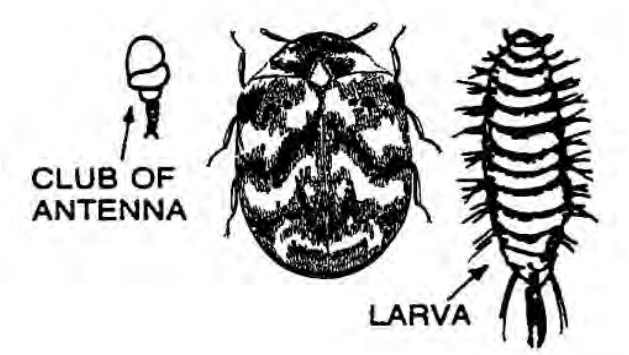


Figure 4-2. Varied carpet beetle, *Anthrenus verbasci*

Furniture Carpet Beetle, *Anthrenus flavipes*

Adults mottled with yellow, black and white, more rounded than varied carpet beetles, cleft at tip of wings. Larvae torpedo-shaped, head wider than rear, darker than varied carpet beetle.

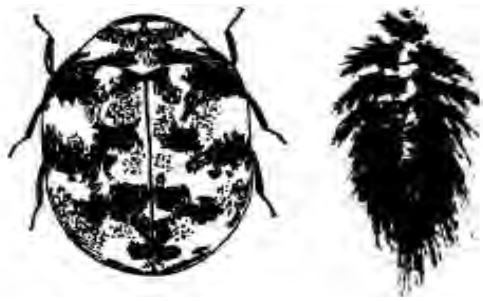


Figure 4-3. Furniture carpet beetle, *Anthrenus flavipes*

Common Carpet Beetle, *Anthrenus scrophulariae*

Adults round-oval, about 1/8 inch long, black with orange red scales. Scalloped band of orange down center of back. Larvae reddish brown, with hair extending outward from entire body.

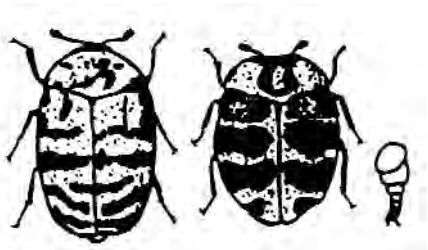


Figure 4-4. Common carpet beetle, *Anthrenus scrophulariae*

Varied carpet beetle complete about one generation per year. The larvae pass through 5 to 16 larval instars. The female lays an average of 30 eggs. With only one generation per year and an average of 30 eggs per female, this species' potential capacity for rapid reproduction and infestation is limited.

The life cycle of the furniture carpet beetle may be completed in as little as three months. Under ideal conditions, this species may be completed in as little as three months. Under ideal conditions, this species may complete up to four generations per year, although two per year is the more likely situation. Each female lays an average of 70 eggs. This species is extremely destructive to carpeting, upholstered furniture, clothing and natural fiber brushes.

The common carpet beetle, which has also been known as the buffalo bug, seems to be less common in the eastern part of the United States. The common carpet beetle is capable of completing one generation in 78 days, although the average is closer to three months. Thus, one pair of carpet beetles is capable of producing several thousand offspring in a one-year period.

Black Carpet Beetle

The black carpet beetle is a serious fabric pest in the eastern states. In these areas, it is considered the most destructive of all carpet beetles. It is also common in the western states. The larvae are extremely active feeders and will readily burrow and enter food or food containers that are not perfectly sealed. The searching habits of the larvae frequently result in their appearance in containers of non-food materials. They occasionally feed on cereal products, but dead bodies of insects are the preferred food of this species. For this reason, black carpet beetles are frequently found in cereals and grains that are infested with stored product pests.

Black carpet beetle infestations that are found in homes and industrial buildings frequently begin with a buildup of the population in bird nests, abandoned wasp or bee nests and dead rodent bodies that are located in attics, chimneys, wall voids or basements. Larvae initially located in these situations will freely migrate into the living quarters of the building and infest any suitable food materials.

Under ideal environmental conditions, this species requires about one year to complete a generation. The larvae will pass through 6 to 20 molts and may require up to 650 days to complete development under poor environmental conditions. The last larval instar typically does not pupate until encountering suitable environmental conditions. Pupation typically occurs in protected situations.

Carpet Beetle Management

Carpet beetles are among the most difficult indoor pests to control because of their ability to find food in obscure places and to disperse widely. Control success depends on integrating the use of sanitation, exclusion and, where necessary, insecticides.

Monitor for adult carpet beetles using sticky traps baited with an appropriate pheromone. Placing several traps throughout a building show the area the beetles are coming. These traps are also useful for monitoring the effectiveness of control applications. Pheromone traps can also be used to augment other control methods when used to attract adult males in small, confined areas. Check all traps once or twice a week.

Eliminate accumulations of lint, hair, dead insects, and other debris that serves as food for carpet beetles. Destroy any badly infested clothing, rugs, or other items. Bird, rodent or bee and wasp nests may harbor infestations, as may spider webs with their accumulation of dead insects. Cut flowers brought into a building may harbor adult beetles.

Regular and thorough cleaning of rugs, draperies, upholstered furniture, closets, and other locations where carpet beetles congregate is an important preventative and control technique. Frequent, thorough vacuuming is an effective way of removing food sources as well as carpet beetle eggs, larvae and adults. Fabrics can be protected by keeping them cleaned, because food and perspiration stains on fabrics attract carpet beetles that feed in these areas. Mounted animal specimens, such as museum specimens or trophies, should be regularly cleaned or periodically placed in a freezer for several hours. Stored woolens, linens and furs should be periodically inspected, then aired, brushed and hung in light. If infestations are found, launder or dry clean these items before storing to destroy carpet beetle adults, larvae and eggs. Be sure cleaned items are sealed in a protective plastic bag or other suitable container.

Apply residual insecticides as spot applications. Confine insecticide applications to the edges of floor coverings, under rugs and furniture, on the floors and walls of closets, on shelving where susceptible fabrics are stored and in cracks and crevices and other lint-accumulating areas. Use dust formulations, including desiccants, in attics and wall voids and other inaccessible places. Fumigation may be necessary when infestations are extensive, although success can be limited by the ability of the fumigant to penetrate all of the areas in which carpet beetles hide. Fumigants, such as naphthalene, can be used in small, tightly closed containers. Insecticide-impregnated resin strips labeled for control of carpet beetles on fabrics are usually more effective in protecting susceptible objects inside enclosed containers. These strips slowly release an insecticide vapor, providing prolonged protection. Infested furniture or similar objects can be removed from the building and treated in fumigation vaults. Some insecticides may cause staining or cause fabric dyes to run, so when in doubt, test the chemical on an inconspicuous part of the fabric before making a complete application.

Clothes Moths

The three types of clothes moths are webbing clothes moth - *Tineola bisselliella*, casemaking clothes moth - *Tinea pellionella* and the carpet moth - *Trichophaga tapetzella*. Clothes moths belong to the insect order Lepidoptera. They undergo complete metamorphosis from larvae to pupae then adults. Although many adult moths are attracted to lights, clothes moths are not. They hide when disturbed, and adults are rarely seen close to the source of infestation. Larvae of clothes moths spin silken webs, which may be the only sign of the pest's presence.

In past years, sheep treated with chlorinated hydrocarbon insecticides such as endrin, toxaphene, or DDT to protect them against external parasites, supplied insect-resistant wool. However, newly produced woolen items are more susceptible to clothes moth infestation because these persistent insecticides are no longer being used on sheep. As a result, there has been an increase in clothes moth problems, requiring other types of protective measures. Heavy reliance on synthetic fibers has helped reduce the clothes moth problem.

The larvae are the only damaging stage of these pests. Adults of the clothes moths do not feed and are short lived. Clothes moths are more limited in their diet than carpet beetles. The larvae of these moths feed mainly on contaminated wool and other materials containing keratin.

Identification

Clothes moths are small and delicate, rarely over 3/8 to 1/2 inch in length. Unlike most species, these moths are not attracted to lights, but prefer darkness, and when disturbed will rapidly conceal themselves in folds or other secluded places. Larval identification is best based on the feeding damage rather than specific morphological (body) characteristics. The carpet beetles can be identified in either the larval or adult stage. Adult carpet beetles can generally be separated by body shape, coloration and the presence or absence of a cleft at the rear of the forewings. The larvae are characterized by body shape and the arrangement of hairs and tufts of hairs on the body. Diagnostic characteristics of the adults and the larval feeding damage of lepidopterous fabric pests are presented below:

Webbing Clothes Moth,*Tineola bisselliella*

Larvae spins webs freely over feeding surface and produces tunnels or tubes for protection. Copious amounts of fecal material scattered throughout feeding area. Wings of adults are uniformly golden or buff colored.

Figure 4-5. Webbing clothes moth, *Tineola bisselliella*

Casemaking Clothes Moth, *Tinea pellionella*

Entire larval stage spent in case, case dragged behind larvae as new feeding areas sought. Case covered with fecal pellets or bits of woolen fiber. Adults are brown with three dark spots on each forewing.

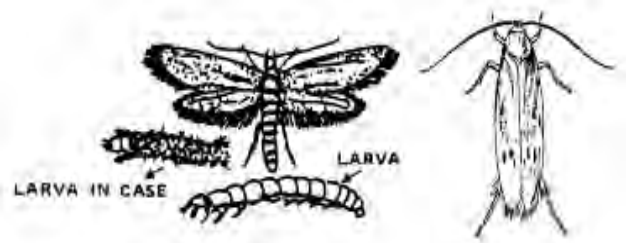


Figure 4-6. Casemaking clothes moth, *Tinea pellionella*

Carpet Moth, *Trichophaga tapetzella*

Figure 4-7. Carpet moth, *Trichophaga tapetzella*

Larval feeding damage similar to webbing clothes moth and frequently extends deeper into materials. In adults, the basal one-third of forewings is black, outer portions mottled white, black and gray.

Webbing Clothes Moth

The webbing clothes moth is the only species of clothes moth commonly encountered throughout the United States. It appears to be the most important fabric pest in the southern states. Like other moths, this species passes through four developmental stages. Under ideal conditions, it will complete one generation in 40 to 50 days. Under marginal conditions, this species may require up to one or two years to complete its development.

A newly emerged first instar larvae will wander until it finds a suitable place to feed (e.g., soiled place on woolen cloth). Unless conditions become unfavorable, it will settle down and feed at this location until approaching pupation. When the young larva finds suitable food, it spins a silken tube from which it feeds. This webbing is frequently covered with fecal pellets and cloth fibers, which is characteristic of this species.

Casemaking Clothes Moth

The casemaking clothes moth is distributed throughout nearly all of the populated areas of the world. This species is relatively rare in northern areas of the United States. The life cycle of this species is very similar to the webbing clothes moth. Unlike the webbing clothes moth, this species covers its body with a portable silken case. Once covered by the case, the entire larval period is spent within it, and it is dragged behind as new feeding areas are sought. The case is often composed of dried fibers interwoven with silk, creating a multicolored effect. Unlike the webbing clothes moth, this species does not spin copious webbing over its food material. This species eats out well-defined, clean-cut holes. When the larval feeding is completed, it frequently crawls onto vertical surfaces to pupate. Consequently, it may be found on walls, partitions or other similar structures when pupating. Pupation occurs in the larval case.

Carpet Moth

The carpet or tapestry moth is not commonly encountered in the United States, but can occasionally become established and cause considerable damage to heavy fabrics and pelts. The larvae normally feed in silk-lined burrows within the infested material. Damage is caused by both feeding and severing of fibers, which are used in construction of the burrows. There are usually two to three generations per year.

Clothes Moth Management

Control of clothes moths depends on preventing infestation, protecting fabrics and selectively using insecticides when necessary. Low humidity inside creates an environment unsuitable for clothes moth development. Building construction free of many tiny cracks and crevices also helps limit clothes moth problems.

Regular, thorough cleaning of susceptible clothing, carpets, closets and storage areas is an important factor in clothes moth control. Strong vacuums should be used to remove eggs and larvae. Clothing and other fabrics should be periodically shaken and brushed to remove these insects or their eggs with special attention given to seams, collars and cuffs. To avoid attracting moths, launder or dry clean soiled fabrics before storing or hanging in a closet. Whenever possible, store garments, blankets, linens and rugs in tightly sealed boxes or containers. Cold storage at temperatures between 40 and 42 degrees F, can further protect expensive clothing and furs. This is also effective in killing moths, if they are first exposed to rapid changes of temperature; for example, a sudden change from 50 to 18 degrees F before storage at 40 to 42 degrees F.

Pyrethrin insecticides provide quick knockdown of clothes moths. Most can be sprayed directly on fabrics if needed (in situations where fabrics cannot be laundered or dry cleaned). Some pyrethrin insecticides do not leave persistent toxic residues; therefore, they are especially suitable for clothes moth control. Use a residual spray along baseboards, margins of carpets, in closets and in storage areas. Also spray under furniture and other areas where moths occur. Before treating any fabric with an insecticide, test a small, inconspicuous part of the fabric to be certain the spray will not cause staining or running of dyes.

Stored Product Pests

Learning Objectives:

After completion of the study of Stored Product Pests, the trainee should be able to:

- Identify common stored product pests.
- Identify factors that contribute to pest infestations in stored products.
- List the key features in the life cycle and habitat of common stored product pests.
- Discuss monitoring and survey techniques for stored product pests including pheromone use.

There are over 100 species of pests found infesting dried plant and animal food materials. Excluding cockroaches, mites and ants, the majority of stored product pests belong to the orders Coleoptera (beetles) and Lepidoptera (moths), but can include birds, rodents, fungi, microorganisms and other pests. The occurrence of these pests in homes, restaurants or other structures usually originate from one of two sources. The majority of these pests originate from infested material brought into the building. This typically results when food materials are first stored for a period of time in an area, such as a warehouse, where an infestation already exists. Once a pest is introduced, it may readily spread to other suitable foods in the structure. Some infestations may also originate from the small number of these pests that naturally occur in and around areas where food is stored.

Most stored product pests are cosmopolitan or worldwide in distribution. One reason for the wide distribution of these pests is that grain, cereal, other dried foods and their pests have been shipped with little restriction all over the world. Another reason for their widespread distribution may be related to the static environmental conditions in stored products. An important factor influencing the distribution of any insect species is the range of environmental conditions within which it is capable of living. As you might expect, an insect that is capable of surviving in one geographical area will not be capable of surviving in another area if environmental conditions are not suitable.

Like other insects, stored product pests have a limited range of environmental conditions within which they are capable of moving, feeding and reproducing. However, unlike insects that develop outdoors, stored product insects are not normally exposed to the extremes in different climatic conditions of different geographical localities. For example, while the climates of southern California, Canada, Russia and France differ immensely, environmental conditions in a home or warehouse in each location are likely to be similar.

To control losses from stored product pests, (1) use management methods that prevent pest infestation, (2) eradicate existing infestations and (3) stop the spread of the pests or contamination to other food items. Establish an integrated approach that includes periodic inspection and monitoring, sanitation, exclusion and appropriate chemical and nonchemical controls. Use mechanical techniques such as aerating the stored products for moisture control, controlling storage temperature to reduce moisture condensation or uptake and to prevent development of insects, and rotating or turning the stored products to stop localized pest outbreaks. Never store pest-free items near infested products, in contaminated or infested containers or buildings.

It is beyond the scope of this manual to attempt to discuss all pests of stored products. The information presented here is limited to the four main categories of the most commonly encountered pests.

Birds

Birds can consume large quantities of grain and other items, and they may also contaminate stored food with feces and feathers. Bird feces may contain salmonella bacteria and fungal spores such as Histoplasma that can produce serious intestinal or respiratory infections in people.

The most important way to prevent bird damage is to exclude them for storage areas. Areas where birds are most apt to be a problem are warehouses with large doors kept open. If doors cannot be closed, install nets or strips of plastic or fabric at the entrances. These barriers enable people and vehicles to pass through freely but keep birds out. In all storage facilities, seal cracks and openings that are large

enough for birds to enter. Close off vents and other high-level openings with wire screen having a mesh of 1/4 inch or smaller. Remove or modify ledges that serve as roosting sites or install nets or other barriers to keep birds from roosting in or on the storage facility. Other attractive nearby roosting sites, such as large trees, may need to be eliminated.

Maintain good sanitation so storage areas do not attract birds. Clean up grains or other items spilled during loading, transfer and handling. Be sure that conveyors, railings, ledges and other parts of the storage facility are kept clean and free of food residues. Dispose of spoiled or contaminated products in covered containers and remove these promptly from the area. Be sure the outside surroundings of the facility do not provide adequate roosting and perching for birds. With persistence, certain species such as pigeons can be trapped. Trapped birds are generally released in an area distant from where they were caught.

Avicides are not generally effective in controlling birds when there is an abundance of other food in the area. If you use avicides, place them in locations where there is no risk of contaminating any stored food products. Whenever possible, use materials that repel rather than kill pest birds.

Trapping, repelling or poisoning pest birds requires considerable experience and expertise. Permits may be required from the Arkansas Game and Fish Commission and USDA Wildlife Services for some species. Extreme care is required to prevent injury of protected non-target species.

Rodents

Rodents such as rats and mice are troublesome pests of stored food. Rodents can chew through wood and other materials to get to food sources. They are good climbers and can squeeze through small openings. Rats and mice populations can rapidly build and consume or contaminate large quantities of stored food. They contaminate stored products and storage facilities with their urine, feces and hair. They also damage cloth, plastic and paper bags or cardboard boxes used to package stored products. Rodents within a storage facility may also chew on electrical wiring and cause serious fire hazards or equipment malfunction.

Exclusion

The most important control method for rodents is rodent-proofing. To exclude rodents from storage areas, seal openings with heavy-gauge sheet metal, heavy wire screen with a mesh of 1/4 inch or less or concrete with heavy wire screening embedded in it. Attach metal plates to the bottoms of doors to reduce the gap to 1/4 inch or less and prevent rodents from entering. Modify foundations of buildings with concrete or metal barriers to stop rodents from digging their way in. Eliminate dead spaces including double walls, false ceilings, enclosed staircases, boxed plumbing and voids under cabinets.

Sanitation

Sanitation is important in preventing rodent buildup. Spilled grains and other food items around the periphery of a building attract rodents and encourage them to nest nearby. Be sure all spills are cleaned up quickly and placed in rodent-proof containers or promptly destroyed. Sanitation must also include keeping all storage areas and adjacent spaces well lit, clean and orderly. Eliminate weeds, shrubs and vines that provide shelter and hiding places for rodents. Rodent activity can be more quickly spotted in clean, orderly areas, enabling early control.

Trapping, Baiting and Fumigation

Rodents infesting a storage facility are controlled by trapping, use of poison baits (rodenticides), fumigation or combinations of these methods. When controlling rodents in food storage areas, consider the following points:

1. Trapping requires daily checking for trapped animals and servicing of equipment. If traps are baited, the bait must be kept fresh by periodic replacement.

2. Poisonous baits must be kept fresh to be attractive; therefore, bait stations need to be checked and refilled frequently. If baits are the multiple-feeding anticoagulant type, rodents must feed on them continually over a period of several days.

3. Once started, bait stations must not be allowed to become empty; otherwise, rodents may recover from the toxic effects.

4. Use of rodenticides, such as poison baits, within storage facilities creates the risk of product contamination and may not be allowed in some situations.

5. Baits may not be very effective as long as the rodents have access to the stored food product.

6. Poisoned animals may wander off and die, making them difficult to find. Dead animals create smells and attract insects such as flies.

7. Fumigation may leave dead animals inaccessible.

When using rodenticides for control of rats or mice inside or around a food storage facility, it is important to identify the rodent species. You need this identification to understand the rodent's habits so you can select the right rodenticide and use it properly. Mice, for instance, tend to restrict their activities to a small area, probably no more than 30 feet from their nest, and never move beyond this area unless food or shelter is eliminated. Bait placed only a few feet away from a mouse nest will have no effect if the mouse never travels near it. Different species of rodents may inhabit different levels of a storage structure, or different colonies of the same species may even be at different levels. An effective rodenticide or trapping program requires locating all rodent colonies and placing control agents within reach of each.

Fungi and Other Microorganisms

Many microorganisms may attack and damage stored food products, including bacteria, protozoa, slime molds, yeasts and filamentous fungi. A large number of these require free water to grow and reproduce. These are only problems if the stored products become wet or are wet when put into storage. The most serious problem of stored grains and other products, however, comes from filamentous fungi adapted to conditions without free moisture. Fungi damage includes reduced germination of grain seeds, discoloration of grains and other products, microbiological heating of the stored material, caking, decay and musty odors. Some fungi produce toxic materials that contaminate stored food products and can cause poisoning if ingested; the most serious of these are the aflatoxins produced by the fungi *Aspergillus flavus* and *Aspergillus parasiticus*.

Many conditions promote fungal development in stored foods. These include high moisture, low temperature, insect or mite presence, damage to the grain or other stored products, degree of fungi invasion before items are put into storage and the amount of foreign material present with the stored product. The length of time items are in storage and the amount and type of air circulation in the area also influence fungal development.

Several things should be done to reduce problems with microorganisms in stored foods. Moisture control is very important. The length of time items are to be stored influences the amount of moisture that must be removed before storing. For example, grains held for long-term storage (greater than two years) usually must have no more than a 13.5 percent moisture content. On the other hand, grains may usually be stored for four or five months at moisture levels of 18 percent without fungus problems. Differences in temperature between the stored product and the surrounding area may cause condensation of water vapor, thereby producing wet spots which favor fungal growth. To control temperature and condensation in storage containers and to provide air circulation, occasionally turn the material or transfer it from one container to another.

Some stored product insects carry in fungal spores on their bodies that may infest stored food. Moreover, insect-feeding damage makes some items more susceptible to feeding by other insects and fungi invasion. Large accumulations of insects may alter the temperature and moisture content of a stored product and may provide more ideal conditions for fungi. Therefore, controlling stored product insects can help reduce fungal problems.

Insects

Stored product insects are small and often difficult to detect. Eggs or larvae commonly pass unnoticed from one part of the food-handling system to the next. These are important economic pests that contaminate stored food with their excrement, cast skins, dead bodies and webbing. They consume or damage large quantities of food. In damaging packaging materials, they cause indirect food damage and further economic loss.

Several species of beetles, weevils and moths are common stored product insects. Descriptions of some of these follow. Management guidelines for these insects are included together, following the descriptions, as the control principles are the same.

Beetles

Sawtoothed Grain Beetle
Oryzaephilus surinamensis

Merchant Grain Beetle
Oryzaephilus mercator

The sawtoothed grain beetle and the merchant grain beetle are similar in appearance and easy to confuse (Figure 5-1). Adults are about 1/10 inch long and reddish brown to dark brown. Lateral margins of the thorax contain six sawtoothed projections on each side. These are long, narrow beetles with characteristic flattened bodies, giving them access to small cracks and crevices. Both species have well developed wings, but the sawtoothed grain beetle has not been seen flying. Adults of both species are usually seen running rapidly over stored food. Larvae have brown heads. Their bodies are yellowish, elongated and segmented with three pairs of legs. They crawl actively during feeding.

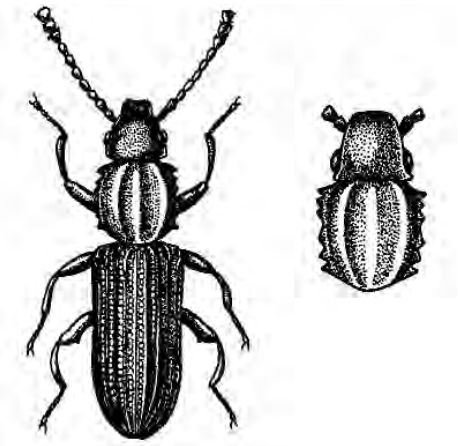


Figure 5-1. Sawtoothed grain beetle, left, and merchant grain beetle, right.

Adult females lay between 45 and 285 eggs singly or in small batches in or around suitable larval food sources. Eggs hatch in about eight days. Larvae pass through two to four instars over an average of 37 days, and pupation takes another six days. Temperature and humidity affect the development time and the number of larval instars.

Sawtoothed grain beetle larvae feed on items such as rice, wheat and nutmeats. These insects probably cannot attack whole, undamaged grains, so they may be associated with other whole-grain pests and feed on the kernels damaged by the other pests. The merchant grain beetle is not a major pest of grains or cereals, preferring seeds and nuts.

Confused Flour Beetle
Tribolium confusum

Red Flour Beetle
Tribolium castaneum

The confused flour beetle and the red flour beetle are the most common and serious pests of flour, cereal and broken grains (Figure 5-2). They are closely related, similar in appearance and often occur together. Flour beetles are members of the large coleopteran family Tenebrionidae, commonly known as the darkling beetles. They emit a foul-smelling, gaseous secretion when disturbed. Adults are about 1/7 inch long, flattened and shiny reddish brown. Antennae of the confused flour beetle terminate in four segments that gradually enlarge to form a club-like shape, whereas antennae of the red flour beetle abruptly terminate in three larger, club-like segments (Figure 5-3).

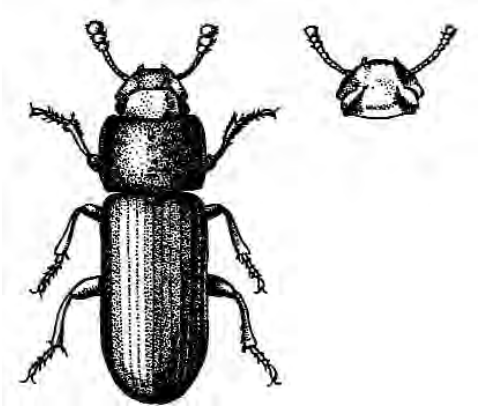


Figure 5-2. Red flour beetle, left, and confused flour beetle, right.

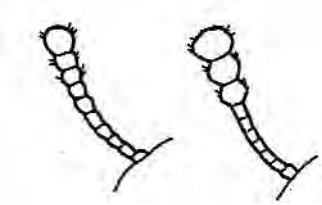


Figure 5-3. Antennae of the confused flour beetle terminate in four segments that gradually enlarge to form a club-like shape. Antennae of the red flour beetle abruptly terminate in three larger, club-like segments.

Adult flour beetles live up to two years. Females produce 400 to 500 eggs in their lifetime, laying two or three per day. Eggs hatch in five to twelve days. Larvae pass through 5 to 18 instars, typically seven or eight, over a period ranging from one to four months. Larvae are slender, wire-like and whitish-colored with yellow tinges. They are distinguished from other stored product insect larvae by the prominent, two-pointed termination of the last body segment (Figure 5-4).

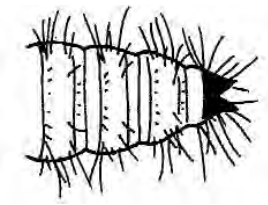


Figure 5-4. Larvae of flour beetles have a prominent two-pointed termination of the last body segment.

Like grain beetles, flour beetles usually do not attack whole grains. They feed on damaged grains, flour, cereals and other stored products. Their small size provides them access to closed containers that would normally be insect-proof. Adult beetles run quickly when disturbed. In addition to feeding damage, they produce secretions that contaminate the material they feed on giving it a disagreeable odor and taste.

Granary Weevil
Sitophilus granarius

Rice Weevil
Sitophilus oryzae

Weevils are distinguished from other beetles by the slender elongation of their heads, a feature responsible for the common name of snout beetles. The granary and rice weevils are serious grain pests (Figure 5-5).

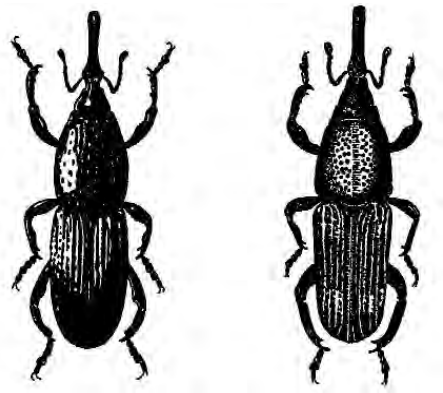


Figure 5-5. Granary weevil, left, and rice weevil, right.

Several features distinguish the granary weevil from the rice weevil. The granary weevil is about 1/8 inch long and shiny dark brown or black. The top-central area of its thorax is covered with elongated depressions or punctures. Adults have nonfunctional, vestigial wings. By contrast, the rice weevil is a good flyer and is slightly smaller. It is reddish brown to black and usually has four reddish or yellowish spots on its elytra. The top-central area of the thorax is covered with round punctures.

Both species bore holes into grain kernels to deposit their eggs. Larvae feed and pupate inside kernels and also feed on caked flour and tightly compressed cereals. Granary weevils have become adapted to living entirely in stored grains and never forage in the wild for food, hence their lack of wings. Rice weevils, however, fly to fields and infest grains such as corn, rice and wheat. After harvest, infested grain mixed with clean grain causes widespread contamination during storage.

Females lay approximately 200 to 300 eggs during their lifetime. Rice weevils produce more eggs than granary weevils. Larvae of both species pass through four larval instars over a period of three to five weeks and usually have four generations per year. Adults of the granary weevil live from seven to eight months when food is abundant. Adults of the rice weevil live three to six months.

Cigarette Beetle
Lasioderma serricorne

Drugstore Beetle
Stegobium paniceum

Cigarette and drugstore beetles (Figure 5-6) are members of the Anobiidae family, which also includes deathwatch beetles. Adults can be distinguished by their humped appearance due to their downward-bent head and prothorax. The cigarette beetle is reddish yellow to brownish red. Adults are about 1/8 inch long. Females produce about 30 eggs over a three-week period; these usually hatch within one week. Eggs are attached to sources of stored food such as tobacco, rice, raisins, grains, pepper and many other stored products. Larvae are curved, plump, hairy and yellowish with a light brown head. The larval stage lasts from five to ten weeks, and three to six broods are produced in a year.

Adults of the drugstore beetle are almost the same size as the cigarette beetle. They are reddish brown and can be distinguished from the latter by the longitudinal striations, or ridges, on their elytra. They are also less humped.

Drugstore beetles usually have one to four generations per year. They complete a life cycle in about two months. Larvae, which resemble those of the cigarette beetle, feed on practically every type of stored product as well as spices, drugs, books and wood. They can survive on items with low food value because of yeast-like organisms in their digestive systems that produce some essential vitamins.

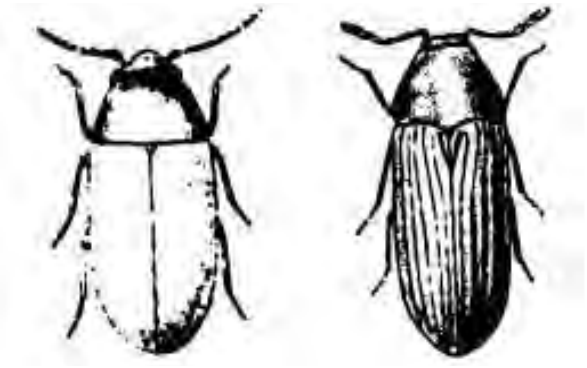


Figure 5-6. Cigarette beetle, left, and drugstore beetle, right.

Moths

Moths belong to the insect order Lepidoptera. Larvae of moths infesting stored food products may be confused with beetle or weevil larvae because of their worm-like shape. Unlike beetles and weevils, only the moth's larval stage causes damage. A telltale sign of infestation is the appearance of small- to medium-sized moths in food containers and packaging, flying around or clinging to walls in a room or storage area.

Indianmeal Moth
Plodia interpunctella

The Indianmeal moth (Figure 5-7) is the most common pest of coarsely ground flours (such as whole wheat flour) and cornmeal. It is widespread in grocery stores, warehouses, and kitchens. The Indianmeal moth also infests shelled or ear corn, broken grains, dried fruit, seeds, peas, beans, crackers, biscuits, nuts, powdered milk, chocolate, candy, red peppers, dry dog food, and other commodities. Unlike weevils and other beetle larvae, Indianmeal moths spin large amounts of webbing, further contaminating food products.

Adults of this moth have a wingspan of about 3/4 inch. Wings are pale gray with the outer two-thirds of the forewing colored reddish brown with a coppery luster.

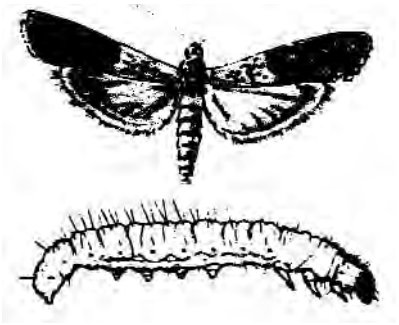


Figure 5-7. Indianmeal moth adult, top, larva, bottom.

Egg laying usually begins in April. Females lay eggs at night, either in masses or singly, and produce 200 to 400 eggs. Larvae are a dirtywhite color but may take on different hues depending on the food ingested. The larva's head and prothoracic shield are brown. Pupation takes place in a silken cocoon. The larval period varies greatly between one and ten months, depending on environmental conditions and available food. The normal complete life cycle of this pest takes about six to eight weeks.

Angoumois Grain Moth
Sitotroga cerealella

The Angoumois grain moth is considered an important pest of stored grain that prefers to lay its eggs in barley, rye, corn, oats, rice and various whole grain seeds. It prefers damp grain in preference to old, dry grain, but it will attack dry grains in storage as well as maturing in the field. The Angoumois grain moth is active at low temperatures. Infested grain has a foul smell and is unpalatable.

The adult has a wingspan of 5/8 inch and is yellowish white, with pale yellow forewings. The hind wings are gray and have a thin, finger-like projection at the tip. The female lays 40 to 300 eggs, which hatch in about a week. The life cycle in warm seasons requires from five to seven weeks. During the winter, the larva is dormant for four to five months, and the life cycle may require up to six months.

Figure 5-8. Angoumois grain moth

Management Guidelines for Stored Product Insects

Stored product insects are tiny and difficult to detect in bulk or packaged food products. They can be freely transported from processing plants to warehouses to grocery stores to restaurants and household and institutional kitchens. Even under the most carefully controlled conditions, some of these pests – in egg, larvae or adult form – will pass from one level of the food handling system to another. Eradication at any one level is virtually impossible due to the size and complexity of the food distribution industry. Once an infestation occurs in one commodity, it can quickly spread to others unless appropriate and timely control measures are taken. Each entity in the complex maze of food distribution, from the producer to the consumer, must assume a role in the management of stored product insects.

Detection and control methods for stored product insects have to be ongoing, not sporadic. Management relies on inspections and monitoring to detect and identify pests, followed by an integrated program of control that includes sanitation practices, exclusion techniques, habitat modification and the careful use of insecticides.

Beetle or moth infestation of a box of cereal or a bag of flour in the home is an annoyance. The infestation may result in the loss of the cost of the product and perhaps spread of the pest to other similar products stored in the pantry or cupboard. Control can be as simple as throwing away the infested materials (or returning them to the grocery store for a refund) and storing uncontaminated food products in insect-proof containers.

Similar infestations occurring in grocery stores, warehouses, or packaging and processing plants can result in considerable loss of investment and revenue. Pest control efforts, therefore, should be proportional to the potential for loss. Major efforts involving sanitation practices, exclusion techniques, habitat modifications and insecticide applications are usually required to eliminate damage. Early detection simplifies the management program, reduces control costs and prevents extensive damage to stored food. Monitoring is used to detect, locate, and identify pests, determine the proper time to apply control techniques and evaluate the success of the management program.

Inspection and Detection

Inspection and detection are necessary parts of a stored product pest management program. They provide information, evaluate control methods used and monitor for reinfestation. Make a complete and thorough inspection of the premises to locate potential infestation sources. Carefully examine stored food such as grains, dried fruit, flour, dog food and seeds. Check around buildings because some stored product insects are attracted to certain flowers and shrubs and outdoor lighting.

Use pheromone traps inside a building or structure to monitor pest activity. Pheromones are available for most of the insects that damage stored food. Traps using mating pheromones generally catch individuals of one sex, usually males. For other stored product insects, traps containing aggregating pheromones are available that attract both sexes. Incorporating food attractants with the pheromone lures enhances the attractiveness of monitoring systems for some insect species. Food attractants can lure larvae and adults of both sexes. With some species, food attractants are used alone.

When using pheromones or food attractants for monitoring, place one trap per 250 to 500 square feet of storage space. For monitoring flying insects, locate traps near storage containers. Put traps inside containers for insects that do not normally fly.

Sometimes the use of more than one type of pheromone in an enclosed area may prevent target insects from efficiently locating traps. Before installing traps for other insect species in an area where one type of pheromone trap is already being used, check with the manufacturer or supplier to determine the effectiveness of such a combination.

Flying insects locate pheromone traps by following a trail of pheromone scent upwind, detecting its increasing concentration in the air. Enclosed areas where traps are located should have some air movement so the atmosphere does not become saturated with pheromone. Keep traps away from bright lights that may repel target insects.

Check traps regularly – daily if there is a low tolerance to stored product insects on the commodity or weekly under normal conditions. At each inspection, record the number of pest insects caught and remove from the traps. Replace pheromones

according to manufacturer's instructions. Change sticky parts of the traps whenever the coating of debris makes them ineffective.

Pheromones or attractants can sometimes be used in traps for control of stored product insects. Trapping may be a preferable control method over insecticides because foods are not exposed to residues. Put traps close to the infestation source for maximum control, and increase the density of traps to about one to each 25 to 50 square feet of storage space.

Exclusion

Prevent insect entry into the storage facility by inspecting grains, cereals, flour and other bulk and packaged products as they arrive. Check packages for holes, webbing, insect frass, eggs, living insects and insect parts. Even new, unused packaging material, such as cardboard, may be an insect source. Immediately return infested materials to the supplier or destroy them. Never store infested materials in the facility unless they can be enclosed in a tight container or refrigerated. Prevent contamination of flour, grains, cereals and dried fruit by keeping in insect-proof containers. Opened bags or boxes must be resealed securely or their contents transferred to sealable containers. Promptly remove empty boxes and bags from the building.

Keep insects out of buildings by using screens over doors and windows. Close off all other openings with wire screening or caulking. If it is not possible to exclude pests from the entire building, at least make sure the storage area is protected. Locate and close rodent holes as stored product insects can enter through these. If rodent baits are in the area, check them for infestation; even stored or unused bait may harbor insects. To keep from attracting insects into buildings, locate outdoor lighting away from doorways. Use sodium-vapor lights rather than mercury-vapor lights for outdoor lighting around warehouses and grocery stores because insects are less attracted to yellow light. Place lighting source away from doors and focus light toward doors. This will draw insects away from doors and toward the lights.

Sanitation

Sanitation is a critical part of controlling stored product insects in homes, grocery stores, warehouses and processing facilities. Clean up spilled materials to eliminate food sources for pests. Seal cracks in shelves and bulk food containers to eliminate places where pests can hide and to keep grains, flour, or other food from accumulating. Keep storage shelves far enough away from walls to leave room for cleaning. Raise shelving in warehouses and other storage areas off the floor to make cleaning underneath possible. Areas where susceptible items are stored should be well lighted for ease in cleaning and spotting pest infestation. Moths may be easier to detect during evening hours when they are active.

Environmental Modification

Manipulation of storage temperatures or humidity can be used to destroy many stored product pests. Heat treatment kills some pests outright, while cold treatment usually blocks their development. For adequate control, it may be necessary to subject products to a prescribed period of high temperatures followed by cold, after which they should be kept stored at a constant, lowered temperature. In general, a temperature of 60 degrees Fahrenheit prevents insect feeding; 40 degrees Fahrenheit kills insects over a period of time. Some products can be frozen to protect them from insect damage.

Desiccants

Dusts, such as silica gel or diatomaceous earth, can be combined with certain stored grains to provide protection against insect damage. These dusts kill target insects by desiccation. Dusts are removed from grain and other stored food before processing by a cleaning operation that also removes other debris. Because sorptive dusts are inert, they do not leave any potentially harmful residues on the food if traces of the desiccant remain.

Insecticides

Insecticides vary according to the pest type and infestation situation. Because food products are involved, residues must never exceed legal tolerances. Apply only those insecticides registered for stored food product sites, and use them in strict accordance with label instructions. Insect resistance to insecticides is an increasing problem, so avoid overusing insecticides. Always employ other control methods along with insecticides. Apply insecticide when insects are most susceptible.

The safest types of insecticides for use on food items are the microbials, such as *Bacillus thuringiensis*. These organisms produce toxins fatal to certain species of insects but have no known effect on people. *Use* only microbial insecticides labeled for control of stored product *sites* that can be applied directly to the product or bulk commodity. Thorough coverage is necessary to ensure that target insects consume some of the microbial organisms.

Compared with organophosphate, carbamate and chlorinated hydrocarbon insecticides, insect growth regulators (IGRs) have a low toxicity to humans. IGRs are chemicals that alter an insect's ability to develop normally or pass through developmental stages at the proper time. For instance, some IGRs prevent larvae from becoming adults, and others force them to pass into the adult stage before they are mature enough to reproduce.

Because of the low toxicity of IGRs, they are usually safe to spray directly onto raw products. (Check the label before application.) Use an IGR where fumigation is not possible or desirable. An IGR is only effective if it contacts the targeted insect pest; therefore, thorough coverage is necessary. Spray a labeled IGR on grains, nuts or other foodstuffs during the filling of storage bins. Use enough spray to thoroughly protect all of the stored product. Spray when insects are at the correct stage of development as described on the IGR label instructions. Occasionally, the application of an IGR extends the larval period, and larvae of pest insects may feed more before they are destroyed.

Fumigants are used to control stored product insects in bulk containers and processed food areas such as truck trailers, railroad cars, warehouses and large storage areas. Fumigants are effective because they penetrate areas where pests occur or might become problems. To be effective, fumigation must take place in a well-sealed area so its concentration can build up to high enough levels. Small quantities of cereals and similar products can be fumigated in containers such as plastic pails or glass jars using dry ice (frozen carbon dioxide); however, if containers are tightly closed immediately after treatment, a vacuum will form that may cause them to implode. Tighten down the lid after the container warms to room temperature. Fumigation is covered in detail in *Classification 3, General Fumigation Training Manual.* Persons fumigating must be certified in Classification 3 – General Fumigation if performing fumigation for more than one person, company or corporation. If the person fumigating is an employee of a large scale, primarily wholesale food manufacturing, processing and storing company or corporation and fumigation is restricted to the company address or addresses, then certification under Classification 8 – Food Related Fumigation is all that is required.

Short-term residual insecticides, such as pyrethrins or pyrethroids, can be used for rapid knockdown of some types of stored product insects. Apply these materials in cracks and crevices and on surfaces that stored products contact. These materials can be applied to bulk containers before adding foodstuffs. They are also used in cupboards and on shelves and areas close to where products are stored, but usually require frequent reapplication if infestations are high.

Residual insecticides, including some persistent pyrethroids, should be selectively used. Residuals are generally applied to surfaces of empty containers to prevent infestation but are rarely applied directly to foodstuffs. Use residual insecticides as a supplement to sanitation measures. They are convenient ways to control stored product pests in inaccessible areas.

There are severe restrictions on pesticide residues on food in food-handling establishments, so be sure residual insecticides are used only according to label instruction and in compliance with federal, state and local regulations.

Mites

Mites occasionally infest stored food. They are known to feed on cheese, flour, grains, dried fruits, dried meats, cereal foods, dog and cat food and animal feeds. Insects or fungi must first damage grains before certain mite species invade. There are over 112 species of mites commonly associated with stored foods. Because mites are extremely small, their presence goes unnoticed. The damage they can cause is sometimes very serious. Infested items become contaminated with living and dead mites, cast skins and fecal material.

Feeding by some mite species alters the nutritional quality of grains and other food. Mites often attack the germ of grains. Flour from mite-damaged grain may become sour and have poor color, and bread made from it does not rise properly.

Some mites are fungus feeders. They invade moldy commodities, bringing spores of certain fungi, and feed on the fungi once they become established. Even after the mites are controlled, the fungi persist and continue to cause damage.

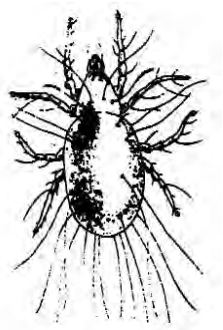


Figure 5-9. Grain mite

Management Guidelines for Stored Product Mites

The most difficult part of managing stored product mites is detecting infestation. Large populations can develop before being discovered and may have already done considerable damage. The stored food may have an odor described as minty, sweetish or musty when it is infested with mites. This odor may be the first indication mites are present.

Use a microscope or hand lens to inspect stored products for moving mites that are small and colorless or cream-colored. Take several samples throughout the stored product and examine each carefully. Check for moldy areas and for mites associated with the fungus. Avoid attracting mites by using sanitation to eliminate residues around the storage facility. Clean storage containers before use to remove debris, mites and mite eggs. Inspect materials before storage to be sure they are pest-free. Maintain proper storage conditions, including moisture-control and air circulation to prevent fungi growth. Keeping the stored product at or below a moisture content of 12 percent also retards development of many species of mites.

Desiccants, fumigants and some types of residual sprays effectively control mites as long as the commodity has been uniformly treated. Treatment of the commodity or storage container for insect control usually destroys mites. Periodic retreatment may be necessary because mite eggs may not have been destroyed. Check the label of the pesticide for permitted uses and follow label instructions carefully.

Table 5-1. Biology of Stored Product Pests

Pest Species	Feeding Damage	Developmental Biology	Food Infested
Angoumois grain moth, *Sitotroga cerealella*	Very important grain pest in the South. Commonly found emerging from decorative corn in home. Internal feeder.	40-400 eggs per female. Six to seven generations per year. Larval and pupal stage found within host.	Mainly attacks whole grain.
Mediterranean flour moth, *Anagasta kuehniella*	Larvae spin large amounts of silk in and over food. Surface feeder.	360-600 eggs per female. Three to four generations per year. Larvae typically leave area of host to pupate.	Prefers flour; also infests wheat, bran, nuts, chocolate, seeds, beans, dried fruits and others.
Indianmeal moth, *Plodia interpunctella*	Larvae spin large amounts of silk in and over food. Most commonly encountered food infesting moth in home and grocery store. Surface feeder.	40-400 eggs per female. Five to six generations per year.	Same host range as Mediterranean flour moth.

Table 5-1. Biology of Stored Product Pests (cont.)			
Pest Species	**Feeding Damage**	**Developmental Biology**	**Food Infested**
Rice weevil*, *Sitotroga oryzae,* and, Granary weevil*, *Sitotroga granarius*	Most important whole grain infesting insects in world. Internal feeders.	50-400 eggs per female. Six to eight generations per year. Larvae and pupae found within host.	Attacks whole grain or pieces of grain large enough for larvae to develop.
Drugstore beetle*, *Stegobium paniceum,* and, Cigarette beetle*, *Lasioderma serricorne*	Most common pantry pest in United States. External feeders.	20-200 eggs per female. Six generations per year.	Very general feeders, attacking almost all dried plant and animal material including drugs and tobacco.
Saw-toothed grain beetle, *Oryzaephilus surinamensis*	Feeding consists of scarring and roughening of surface of food. Very common household pest.	50-300 eggs per female. Eight to nine generations per year.	Very general feeding. Attacks almost all dried plant products.
Confused flour beetle*, *Tribolium confusum,* and Red flour beetle*, *Tribolium castaneum*	Feedings consist of scarring and roughening of surface of food. Usually brought into home in flour.	400 eggs per female. Six to seven generations per year.	Common in flour, also infests cereals, nuts, chocolate, spice, peas and many others.
*These beetles have almost identical life cycles.			

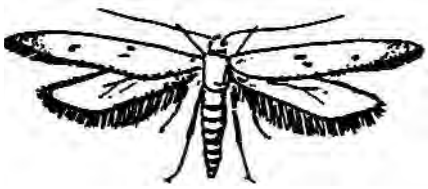
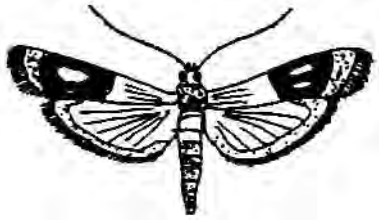
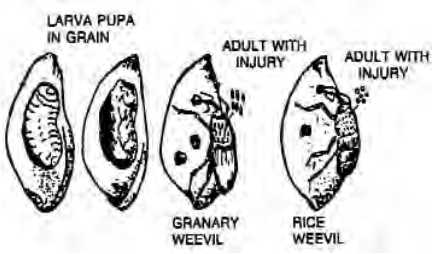
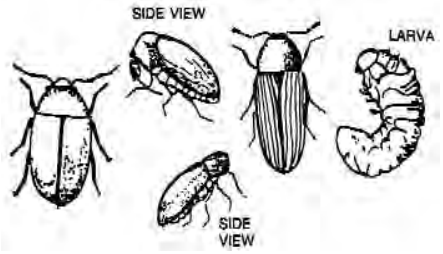
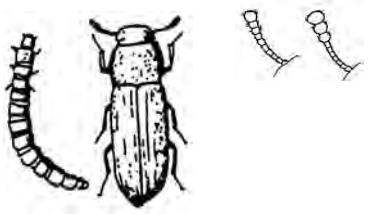
Table 5-2. Identification of Adult Stored Product Pests		
Pest Species		**Identifying Characteristics**
Angoumois grain moth, *Sitotroga cerealella*		Wingspread 1/2 inch. Pale yellow forewings. Gray hind wings which are pointed at end resembling a pointed finger.
Mediterranean flour moth, *Anagasta kuehniell*a		Wingspread 3/4 inch. Front wings gray with wavy transverse bars. When at rest head and thorax raised above abdomen protruding between and above wings.
Indian meal moth, *Plodia interpunctella*		Wingspread 3/8 inch. Basal 1/2 forewing grayish with outer 1/2 as well as head and thorax reddish.

Table 5-2. Identification of Adult Stored Product Pests (cont.)		
Pest Species		**Identifying Characteristics**
Rice weevil, *Sitophilus oryzae,* and Granary weevil, *Sitophilus granarius*		Length 1/8 inch and dark to reddish brown in coloration. Mouthparts drawn into elongate snout or beak. Rice weevils have 4 faint reddish or yellowish spots on the elytra and round or irregularly shaped punctures on the prothorax. Granary weevils lack the pale markings on the elytra, and the pits on the thorax are elongated.
Drugstore beetle, *Stegobium paniceum,* and Cigarette beetle, *Lasioderma serricorne*		Squatty, 1/8 inch in length and reddish brown in coloration. Head retracted into thorax and not visible from a dorsal angle. Elytra of drugstore beetle with parallel lines. Cigarette beetle elytra smooth.
Saw-toothed grain beetle, *Oryzaephilus surinamensis*		Approximately 1/8 inch long, elongate, dark brown and flat. Readily recognized by six sawtoothed like projections, located on the lateral margins of each side of thorax.
Confused flour beetle, *Tribolium confusum,* and Red flour beetle, *Tribolium castaneum*. These beetles are very similar in appearance and have similar biologies.		Elongate flattened, shiny reddish brown and about 1/8 inch in length. Antennae gradually enlarged to form a club. The antennae of the Confused flour beetle are gradually enlarged toward the tip, ending in a club of 4 segments. The antennae of the Red flour beetle are abruptly club-like with the club consisting of 3 segments. Also the sides of the thorax of the Confused flour beetle are almost straight, while those of the Red flour beetle are curved.

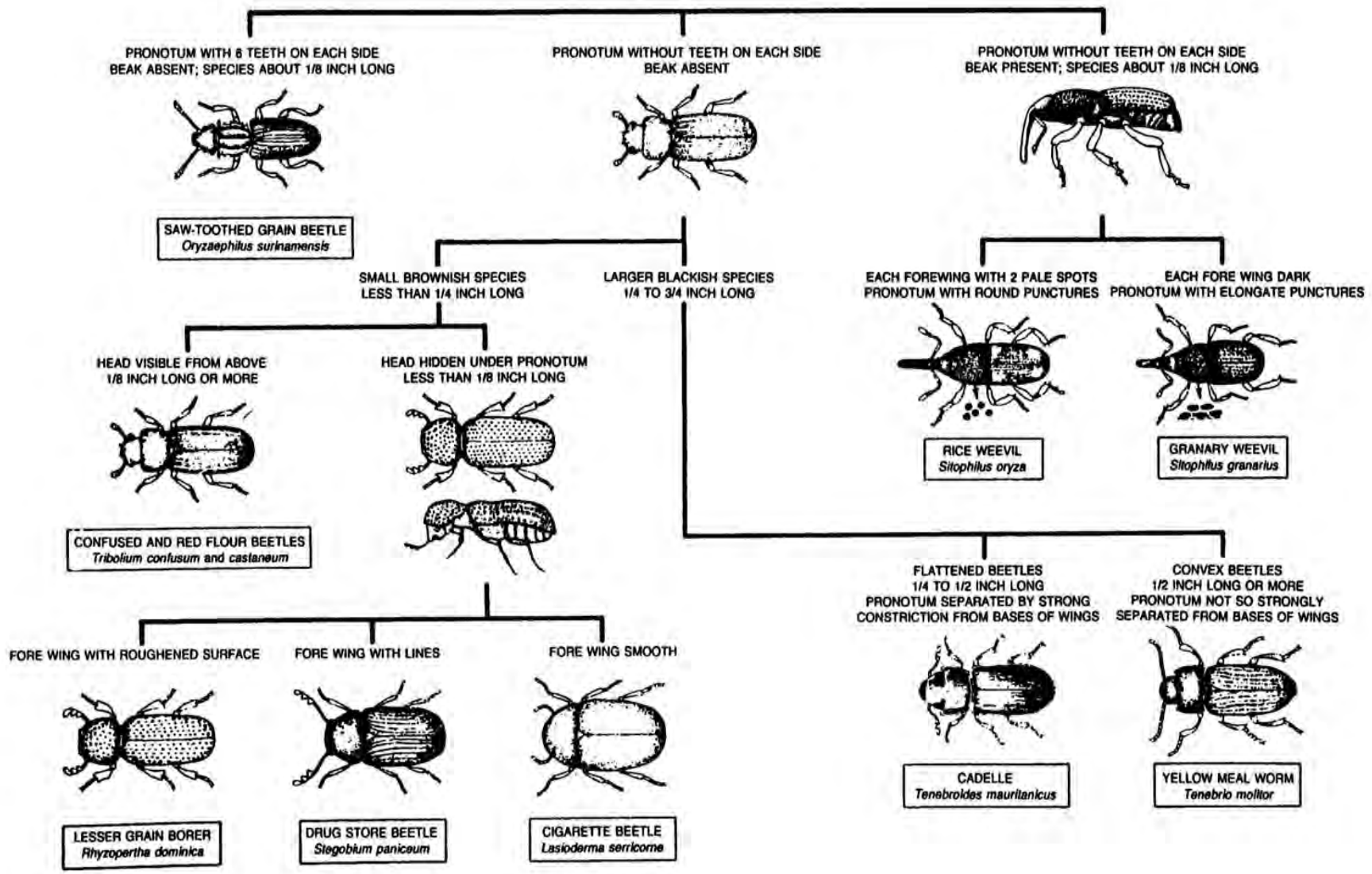


Figure 5-10. Beetles: Pictorial key to some species commonly associated with stored foods

Occasional Invaders

Learning Objectives:

After completion of the study of Occasional Invaders, the trainee should be able to:

- Identify key occasional invaders.
- Identify the key features in the life cycle, habitat and appearance of miscellaneous invaders.
- Discuss integrated pest management procedures for common miscellaneous invaders.

Occasional invaders are pests that do not usually live and breed inside buildings but can wander or migrate seasonally into structures. Some of these pests are associated with trees, shrubs, mulch or other habitats conducive to pest development. Others are attracted to lights at night. Some are dislodged from preferred habitats by management procedures that make the environment unsatisfactory. Environmental extremes such as excessive rainfall, drought, temperature changes or poor drainage around a building may stimulate pest movement indoors.

Many of these pests can be managed by eliminating conditions near the structure that allow them to build up to large numbers. Generally, sanitation or basic landscaping will help eliminate pest-infested sites near structures. Also, pest exclusion, using caulking, weather-stripping, screening of vents and lighting location can solve many problems with occasional invaders.

Mites

Clover Mite

Like other mites and hard ticks, the clover mite passes through four stages in its life cycle: egg, larva, nymph, and adult. The female lays bright red eggs in foundation cracks, under bark, and other protective locations. The newly hatched larvae move to clovers and other plants to feed. After a short feeding period, the larvae return to protected areas to molt. They feed and molt three times before becoming adults. They suck juices from their host plants but do little damage.

The clover mite, although about the size of a pinhead, is one of the larger mite species. The color may vary from brown to pale orange, but when seen in a structure, they are typically blood red. This species is characterized by its two front legs extending forward as long or longer than its body. Like other mites, this species has eight legs.

Figure 6-1. Clover mite

The clover mite problem exists over much of the country. In only a few of the southeastern states do structures seem to be free of invasion by these pests. Outdoors, this species feeds on a variety of herbaceous plants, especially alfalfa and clover. The clover mite most frequently becomes an annoying household pest in housing developments where new lawns have been established and where there is a heavy growth of well-fertilized vegetation next to the foundation.

The feeding activity of these mites seldom causes extensive damage. The problem arises when the host plant dries up or is removed. The mite seeks a new host and will enter a structure through window orifices, doorsills and any other available openings. This pest enters structures in massive numbers in the fall and early winter months. The mites are searching for hibernating sites in response to prevailing cooler temperatures and a decrease in the succulence of host plants. Adults are capable of overwintering within a structure. A second migratory period may occur in the spring. This is a movement from hibernating sites to a food source.

The clover mite does not bite man and normally does not feed on plants in a structure. The problem arises from their mere presence. A heavy migration may result in several hundred thousand mites entering a structure. These mites get into clothing, beds, and food. It is nearly impossible to remove them, and if crushed, they will stain surfaces red.

Mite Management

In areas where clover mites are a recurring problem, it is advisable to set up a program to prevent them from entering the home. Once inside they can be killed with certain sprays, but they are more likely to show up again. Prevention can be obtained through chemical and cultural practices.

Home invasion is more likely to occur when grass and shrubbery grow against foundation walls. Since it is difficult for these mites to crawl across rough surfaces, a barrier 18 to 24 inches wide of pea gravel or bare soil along foundation walls will stop many of them. A chemical barrier may also be sprayed adjacent to the foundation. If possible, the inside of the foundation wall should be treated. Most of the miticides with longer residual activities are effective, but check label carefully to insure the chemical selected is registered for this use.

Insects

Silverfish and Firebrats

Silverfish and firebrats are flattened insects that are broad near the head and tapered toward the rear of the abdomen. They are wingless, covered with scales and have long slender antennae. They have three long slender appendages at the rear of the body. These structures give these insects the common name “bristletails.” These insects develop without metamorphosis and they have chewing mouthparts. These insects make up the order Thysanura, which are among the most primitive insects.

Silverfish are covered with silvery-gray or tannish gray scales. Silverfish live in damp areas indoors or out, usually underneath boxes, boards and debris.

Firebrats have mottled tan and gray scales, which often rub off to show a yellowish colored body wall. Firebrats prefer very warm areas indoors where temperatures are 90 degrees F or above. They are usually found near heating units, fireplaces and steam or hot water pipes if the areas are not too dry.

Silverfish and firebrats feed upon starchy and proteinaceous materials such as natural fabrics, rayon, highly refined paper, glue and paste, books and linens. They frequently leave yellowish stains on the materials they feed upon.

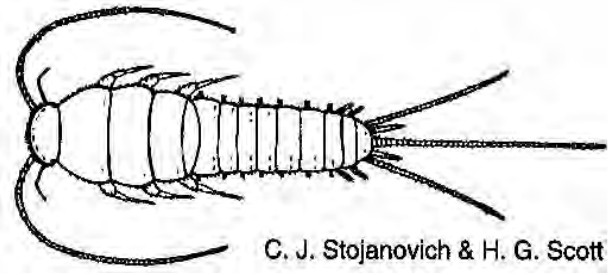


Figure 6-2. Silverfish

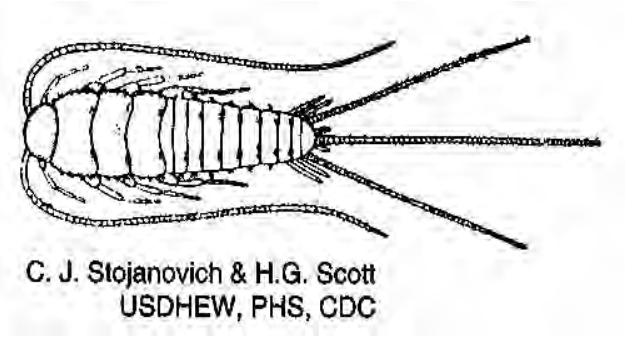


Figure 6-3. Firebrat

Silverfish and Firebrat Management

Due to their nocturnal habits, silverfish and firebrats are often not noticed during the day. If possible, make observations or surveys of silverfish or firebrats during the night using a flashlight. They may also be monitored with sticky traps. These insects may go unnoticed until populations get large or damage becomes severe. Control may be difficult because it is hard to locate the infestation sources.

Keep silverfish and firebrats from entering buildings by caulking or otherwise closing outside openings. Caulk cracks and fill other openings inside to eliminate hiding places. Moisture attracts these insects, so it is important to repair leaking pipes and drains and insulate water pipes to prevent water condensation. Wherever possible, eliminate sources of food; store flour, cereals and similar items in tightly sealed containers.

Labeled sprays or dusts should be applied to all potential hiding places, such as cracks and crevices in basements, cupboards, closets, behind baseboards, wooden partitions and around water pipes. Dusts are useful for treating wall voids, crawlspaces and attics and for use in dry areas where visible residues are not objectionable. Space sprays may be useful especially in attics. Occasionally, it may be necessary to treat the plant mulch around the outside of the building. In this case, use a formulation

other than an oil base spray to avoid plant injury. Consult pesticide labels, Arkansas Extension Service recommendations or pesticide dealers for insecticides recommended for silverfish and firebrat control. Follow the label directions.

Centipedes and Millipedes

Centipedes are flattened, many segmented arthropods that have two body regions (head and abdomen). They have one pair of legs on each body segment, and one pair of long antennae. The claws of the appendages of the first abdominal segment contain poison glands. Their poison functions to paralyze their prey. Centipedes are predatory and feed on small insects and other related animals. Only one species, the house centipede, commonly lives indoors. Most species live outdoors in moist areas found under leaves, stones and debris.

Millipedes like centipedes are arthropods, but they are not insects. They are worm-like in appearance and the body is divided into two regions (head and abdomen). They have one pair of short antennae and most of the body segments bear two pairs of legs. They characteristically roll or curl up into a ball when disturbed.

Figure 6-4. Centipede

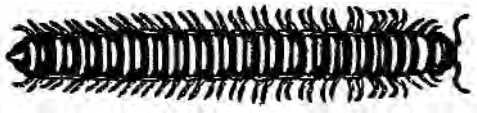


Figure 6-5. Millipede

Their food consists of decaying vegetable matter, tender roots and green leaves. Large numbers of millipedes are usually associated with large amounts of decaying vegetable matter such as leaves, logs, brush, mulch or grass in combination with ample moisture. Large numbers of millipedes often occur in Arkansas during wet springs that follow mild winters. Millipedes are most common inside homes or other buildings when heavy population pressure, adverse weather, or lack of food causes them to migrate indoors.

Centipede and Millipede Management

Reduction of centipede numbers outside can usually be achieved by removing harborages such as rocks, boards and decaying vegetation. Removing harborages and decaying vegetable matter will also help reduce millipede numbers. Along with cleaning up the area, treating outside foundations and a 12 to 18 inch swath bordering the house with approved insecticides will normally eliminate millipedes.

Springtails

The springtails are a primitive group of insects that on occasion may be of some concern to the homeowner. They are delicate, wingless, soft-bodied insects that typically measure less than 1/16 inch in length. The next to last segment of the body bears a forked appendage that can be pulled under the abdomen and released in a spring-like fashion enabling the insect to jump several inches. The color of the adults may vary from white to blue.

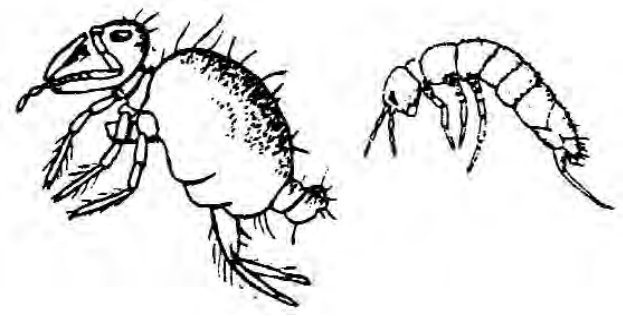


Figure 6-6. Springtails: rounded form (l), elongated form (r)

Although these are among the most common and universally distributed of all insects, relatively little is known about their life history. Springtails may pass through several generations a year and can build up to tremendous numbers in a short period of time. Large populations are typically encountered during the late spring months when temperatures are warm and moisture is plentiful.

These insects feed on decaying plant and animal matter, fungi, algae, bacteria and living plants. They may become pests in mushroom cellars, occasionally damage greenhouse plants and destroy germinating seeds. However, unless populations are large and conditions are ideal, the feeding of springtails is rarely a problem.

Adequate moisture is critical to springtail development. Common habitats include under loose bark, in leaf litter and in lawns or any other areas associated with decaying organic matter. Springtails may breed in a variety of conditions including flowerpots, planters in basements, around kitchen sinks, and similar areas. Massive numbers of these pests may emerge from lawns in the spring and become temporary pests around swimming pools.

Elimination of dark, moist areas of concealment will greatly aid in control of springtails. Residual sprays should be applied to surfaces where springtails occur.

Earwigs

Earwigs are a common group of insects characterized by a flattened, elongated, parallel sided body and a pair of forcep-like appendages on the end of the abdomen. Some species are wingless, but others have a short pair of leathery forewings that cover the first few abdominal segments. These insects are generally brown to reddish brown in color and range from 1/4 to 1/2 inch in length. The pinchers are typically larger and more curved in the males than in the females. Although the pinchers are well developed in most species, they are incapable of penetrating the skin. These structures are used in courtship and defense.

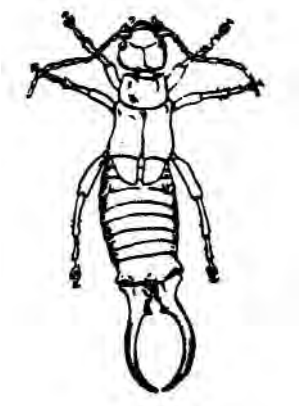


Figure 6-7. Earwig

The female typically forms a hollow nest two to three inches below the surface of the ground or beneath rocks, boards, beside sidewalks, in leaf litter or other similar locations. Most species exhibit some social tendencies. The female stays with and guards the eggs and first larval instars. After the first molt, the immature stage leaves the nest. Most species have only one generation per year and overwinter in either the egg or adult stage.

During the day, the nymphs and adults can be found under logs, rocks, boards, beside sidewalks, in leaf litter and other similar locations. Most species are active and forage at night, chiefly feeding on decaying organic matter, various plant parts and dead insects. Some species are predatory and feed on earthworms and other insects. A few species are occasionally of economic significance as greenhouse, garden and agricultural pests.

Earwigs are typically outdoor species; however, a few may occasionally enter the home, especially during warm weather. They typically do not feed or breed within structures, but because of their relatively large size and fearsome looking forceps, they are of considerable concern to the homeowners.

Earwig Management

The most effective control for an errant earwig or two in the home is purely mechanical. A folded newspaper, fly swatter, broom and dustpan provide quick and inexpensive control. For severe indoor infestations, insecticide sprays should be used only for spot treatment.

Proper scheduling of outdoor applications may increase the efficiency of control. Application of residual insecticides should be made late in the afternoon or early evening because earwigs are active at night. The material should be applied in a band treatment around the entire perimeter of the structure as specified on the insecticide label. It may also be necessary to treat the base of mulched shrubbery or flowerbeds. Because of the high reproductive potential and habitat of earwigs, it is likely that insecticide applications will have to be repeated regularly to achieve a satisfactory degree of control.

Glass jars or tin cans baited with fish or cat food can be buried level with the ground line for use as pitfall traps. The earwigs cannot climb the sides of the container and are trapped. The trap can be cleaned periodically and the trapped earwigs destroyed.

Crickets

Field Crickets

Field crickets have large heads, long thread-like antennae that extend up to 1/2 inch past the tip of the abdomen, and females have spear-like ovipositors (egg laying devices). The hind legs are

well developed for jumping. The adults vary considerably in color, ranging from dark brown to gray to black, with a body length from 3/5 to 1 inch.

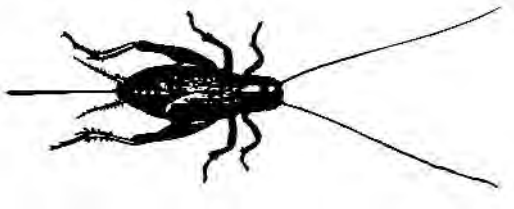


Figure 6-8a. Field cricket

Besides being a household and entryway pests, the field cricket is of considerable importance as an agricultural pest. In many states, they damage seedling cotton plants. They are also occasionally of some importance as a pest of alfalfa, tomatoes, cucurbits, peas, beans, strawberries and others, feeding mainly on the fruiting bodies of these crops.

In Arkansas, the field cricket overwinters as nymphs. The total developmental period in the summer months occupies 9 to 14 weeks.

The field cricket causes the most problems in the adult stage. In many areas, massive numbers of adults develop in the late summer. These adults fly, frequently moving out of lawns or agricultural areas, and are attracted readily to lights around homes, gas stations, supermarkets, motels, and any other illuminated areas. Outside, crickets are pests mainly because of their large numbers. It is not uncommon for the areas beneath streetlights to become slippery where cars have crushed massive numbers of these pests. They may occasionally feed on ornamental plants around the home, but most feeding damage results when the cricket enters the structure. They occasionally eat holes in paper and rubber products and in cotton, linen, woolen or fur garments, especially when these are soiled with perspiration or food. Even nylon, wood, plastic and leather goods can be damaged.

Camel or Cave Crickets

This humpbacked insect is more closely related to katydids than to crickets. It is mottled brown and wingless with very long legs and antennae. Cave crickets are often compared to spiders, but the resemblance is only superficial. Cave crickets prefer dark damp or cool places like basements, crawlspaces and garages. They seldom cause damage.

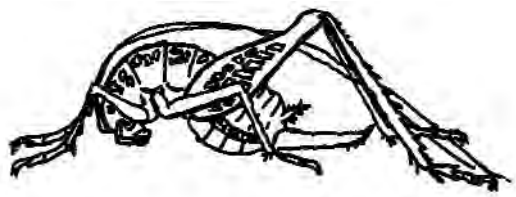


Figure 6-8b. Camel cricket

Cricket Management

The key to managing crickets inside is exclusion. Seal cracks and other openings from the outside that provide access. Caulk or otherwise seal cracks and crevices inside the building that provide hiding places. Behind or under heavy furniture and appliances or in other inaccessible areas, try removing crickets using a strong vacuum cleaner. Weeds and debris around the outside of the building should be removed to eliminate attractive habitats. Change outside lighting to sodium vapor lights or yellow incandescent lights that are less attractive to crickets and other insects. Where possible with commercial lighting, have the light source away from the building and shining towards the building. Crickets will move towards the light source. Garbage and other refuse that serve as food should be stored in containers with tight lids and elevated off the ground on platforms or bricks.

Insecticides should be used only when exclusion and sanitation cannot accomplish control quickly enough to stop the damage within a reasonable time. Use an insecticide registered for indoor use as a spot spray in cracks and crevices and other areas where crickets may hide. Sorptive powders may also be blown into inaccessible areas. Apply a perimeter spray around the building or in other outdoor areas if crickets cannot be controlled through sanitation. Avoid using outdoor spray materials in indoor areas unless the label states this is permissible. Insecticide-impregnated baits or granular formulations of certain materials may also be used outdoors. Granules are suitable in lawns and other areas subject to moisture or frequent watering. Avoid the use of baits or granules if children or pets can gain access to them.

Cricket infestations are usually seasonal. Most often problems occur during the fall as evenings become cooler and the insects seek buildings for warmth and shelter. Because of this, applications of long-residual insecticides are not usually needed indoors for adequate control.

If a large number of crickets are killed due to insecticide applications, the pest control operator should consider cleaning up the dead crickets and disposing of them. This is to avoid potential adverse effects to pets and birds eating the dead crickets. There have been documented poisonings to cats and birds eating insecticide-killed crickets. Dispose of crickets in a manner that will not pose a threat to pets or birds, such as placing the crickets in a plastic bag and placing the bag in the trash collection.

Booklice (Psocids)

Booklice are small, soft-bodied insects. Most are less than 1/4 inch in length. Some outdoor species have wings, but home-infesting species do not. Booklice have chewing mouthparts and elongated antennae. They are usually almost colorless when young but obtain some coloring when mature. Living specimens can be recognized by their small size and erratic movements when running.

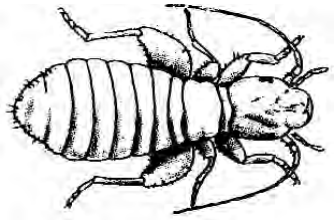


Figure 6-9. Booklouse

There are over 150 species of booklice in the United States, but only a few are normally encountered in homes or businesses. These indoor species feed mainly on fungi and live in humid environments. Large populations may build up in new housing tracts, due to the use of green lumber in wall voids, attics and other enclosed situations. This usually results in sweating, high humidity and the development of fungi. These infestations soon become widespread within the building; however, as soon as the building is heated, the lumber and surrounding areas dry out and reinfestation seldom occurs.

Localized infestations may result from leaky roofs and plumbing, damp basements and crawlspaces. Booklice infestations could indicate a moisture problem in the building. Several species of booklice are also associated with and feed on bird nests, bee and wasp nests, paste in book bindings, dead insects and various cereal products.

Booklice Management

Sanitation is the first step to booklice control. Sanitation refers to the removal or elimination of sources of excessive moisture. If infestations are widespread, it is likely the source of infestation is originating within wall voids or other enclosed situations. In this case, little can be done. It should be emphasized that this situation will be rectified when the heat is turned on in the fall. If bird nests, cereals or cereal products or other vegetable matter are the source of infestation, these should also be removed and destroyed.

Insecticidal control mainly consists of applying residual insecticides to the infested areas; however, space sprays are reportedly effective in garages, attics, etc. Preferably, the insecticide used should not be readily inactivated by high amounts of moisture. If the infestation is widespread within the wall voids, these insecticides can be applied around baseboards, windowsills and other areas where the booklice emerge from the walls. Booklice can cause serious problems in libraries, box manufacturing plants and food storage plants. Treatments to consider for these areas include residual sprays, space sprays and ULV treatments. Treatments must be applied according to label directions and care should be used when applying in food and food container areas.

Ground Beetles

Figure 6-10. Ground beetle

These nimble, soil-inhabiting species occur in a wide range of sizes and colors. The smaller forms may be about 1/8 inch long, while the large species are an inch or more in length. The colors vary greatly from brown or black to metallic red and green. Ground beetles prey upon other insects and related animals in the soil. They may invade buildings through windows, doors or cracks leading to basements. Most do not stay in dry areas. Ground beetles do not damage household structures or fabrics. They are generally considered harmless to

man. However, they can become a nuisance where moisture is difficult to control. The beetles are attracted to lights, and many homeowners mistake them for roaches.

Boxelder Bug

Boxelder bugs often become household pests when they invade structures, crawling into any cracks and crevices they can find. Eventually, some may get into wall voids. Although they do not bite man or damage buildings, furnishings, clothing or food, they can stain curtains and walls with fecal material and they will leave a stain when crushed. However, their mere presence can be a nuisance when crawling and flying about rooms.

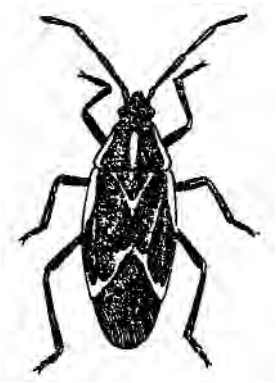


Figure 6-11. Boxelder bug

Adult boxelder bugs are about 1/2 inch long, dark brown to black, with conspicuous red markings on their backs. The young, or nymphs, are wingless but generally similar in shape to the adults. The smaller nymphs are solid bright red, but the older nymphs have some black markings.

Adults come out of winter hibernation in early spring, mate and lay eggs on trees, leaves, grasses, shrubs and stones. Eggs hatch in about two weeks into small, bright red nymphs. Studies on nymphs in cages has shown that they feed on a wide variety of plants including maple, ash, oak, boxelder, tree-of-heaven, mulberry, honey locust, goldenrain tree and numerous other species of plants.

By mid to late summer, they develop into adults and lay eggs for a second brood. Large numbers of nymphs can often be observed in late summer on host plants. After appearing, the second brood adults begin to seek winter quarters. This is when they move into homes or buildings, entering into foundations and pushing into cracks. Many get into walls, attics and under shingles. During the coldest part of winter, the insects are inactive, but during warm days, some will move around inside and outside of a house, especially on walls facing south.

The first warm days of spring bring the bugs out of their protective wintering place in preparation for outdoor activity. Unless they are bothersome, there is a little point in treatment at this time. Those trapped in the home will die during the spring. Boxelder bugs are more common during dry summers. During wet weather, small nymphs are easily drowned. This insect is difficult to control in the adult stage and frequently requires repeated insecticidal applications to ensure contact kill. An insect with similar appearance and habits is the redshouldered stink bug; however, the redshouldered stink bug is almost totally black with red markings on the outer margins of the midsection.

Once inside or when entering buildings enmasse, vacuuming is often the best management method. The vacuum bag needs to be removed from the machine after collecting the bugs. Place the vacuum bag in a plastic garbage bag, and be sure it is tightly closed. Then place the plastic bag in the trash for collection.

Prevention of future infestations involves removal of host trees. This is often not pleasant to the owner, but it is the only way to avoid future infestations of boxelder or redshouldered bugs.

Elm Leaf Beetle

The elm leaf beetle is primarily an ornamental pest feeding solely on elm trees. They prefer to feed on the Siberian elm (*Ulmus pumila*), also called the Chinese elm, over other elm species. The true Chinese elm (*U. parvifolia*) is seldom attacked and the American elm (*U. americana*) seldom suffers significant damage from beetles. However, it can become a household pest. The elm leaf beetle overwinters as an adult beetle, frequently in homes, and sheds in protected places outdoors. Adults are about 1/4 inch long, yellowish to olive green, with a black stripe on the outer edge of the wing cover. In the spring, the beetles leave their over-wintering quarters, fly to nearby elms, mate, and begin laying eggs.

Management includes vacuuming beetles entering buildings and disposing of the vacuum bag in a sealed, plastic bag. Long-term management

requires either properly scheduled insecticide treatments to the trees or removal of the Siberian elms. The latter is often the best management practice. Inside the home their presence can be an annoyance. On rare occasion, they stain materials or walls. They are not known to damage food, fabrics or other household goods.

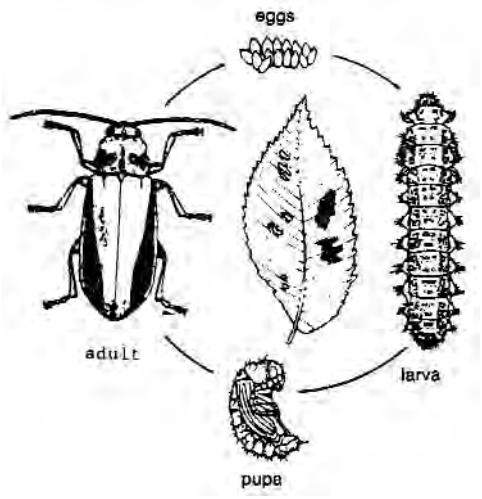


Figure 6-12. Life stages of the elm leaf beetle

Sowbugs and Pillbugs

Sowbugs and pillbugs are common crustacea, belonging to a group of animals called Isopods found throughout Arkansas. They are wingless, oval or slightly elongated arthropods about 1/2 inch in length and slate-gray in color with the body segments appearing as armored plates.

Both pillbugs and sowbugs feed primarily on decaying organic matter although occasionally they damage the roots of green plants. Their normal habitat is outside, but they occasionally wander indoors where they do no damage.

Sowbugs are often called woodlice and possess two tail-like appendages, several pairs of legs and well-developed eyes. They are incapable of rolling into a tight ball. Pillbugs or “roly-polies” lack the tail-like appendages and can roll into a tight ball.

The habits, biology and control of sowbugs and pillbugs are similar. Both animals are slow moving, crawling arthropods. They require high moisture and are most active at night. When resting during the day, they may be found under trash, rocks, boards and decaying vegetation or just beneath the soil surface. A heavy infestation indoors usually indicates a large population outdoors. Mulches, grass clippings and leaf litter often provide the decaying organic matter these bugs need to survive.

The female carries the eggs in a brood pouch on the underside of her body. Often there are 7 to 200 eggs per brood. The eggs hatch in three to seven weeks, and the young remain in the pouch another six to seven weeks. Once the young leave the pouch, they never return. Some species produce only one brood per year, but others may produce two or more. Individuals may live up to three years.

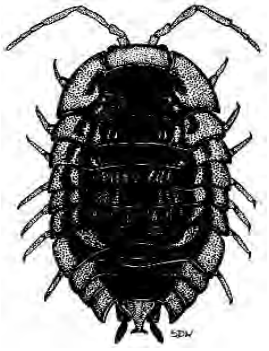


Figure 6-13a. Sowbug

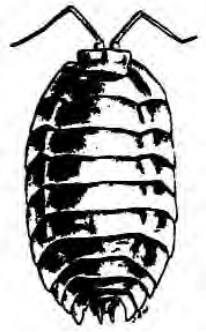


Figure 6-13b. Pillbug

Sowbug and Pillbug Management

Sowbugs and pillbugs cause no damage inside structures. Simple mechanical control, such as a broom and dustpan or a fly swatter, may be adequate. If they become a serious nuisance, elimination of hiding places, food and moisture sources will reduce the infestation. Source reduction outdoors helps considerably. Piles of leaves, grass clippings and fallen fruit should be stored off the ground to eliminate a moist shelter.

Indoor treatment with residual insecticides may kill pillbugs and sowbugs that wander inside. Complete control is difficult to achieve and treatments may not last more than one month.

Usually outdoor treatments are necessary to control sowbugs. Treatments should be to and near foundation walls, around steps or damp areas surrounding the structure. Cracks between sidewalks and the foundation require thorough treatment. Granules or dusts are also useful for treating around foundations and crawl spaces.

Entomophobia: The Fear of Insects

Entomophobia is a term often used to denote a morbid dread or fear of insects or other arthropods. It is considered substantially different from the mental disorder referred to as "delusory parasitosis." In the case of entomophobia, the person dreads any association whatsoever with the particular class of organism, perhaps for a reason and perhaps not. Having been severely stung by bees or ants when young, a person may avoid with irrational zeal any confrontation with any insect in later years. It matters not that the insect may be quite harmless. To that person, it is a bug to be avoided at all cost.

There is a second type of fear of insects. It is not a manifestation of psychic disturbance. Rather, it is a fear born of ignorance of the facts. It may be due in part or entirely to myth, to absence of knowledge or to misstatement of fact. It can assume proportions of mass hysteria. For example, some may have heard, especially when young, that devils darning needles (adult dragon flies and damsel flies) are poisonous or that "killer bees" are headed into the state.

There is a mental disturbance (psychosis), which includes a fear or dread not necessarily attendant, concerning ectoparasites, which may or may not be successfully dealt with. There are many ramifications of this disorder, up to and including suicide. Those afflicted may or may not be aware of their problem; however, if they seek help, they will generally do so to alleviate the symptoms rather than cure the malady. This disturbance is correctly named "delusory parasitosis." It is a delusion that one's body is being attacked or invaded by parasites. This supposed invasion may be external, internal or both.

Persons with feelings of repugnance, imaginary bites and other such feelings must be handled with care. Reasoning and proof of no pest problem seldom satisfies affected persons. These people are sincere in their belief and should be dealt with respectfully. Mental attention is often necessary.

W. G. Waldron has identified certain characteristics or complaints that can immediately lead one to suspect psychotic origins of pest problems. Discussion with the person will frequently disclose some of the following identifying characteristics:

1. The "bugs" are often first noted and described as one color, then later the person changes the color of the culprit.

2. The "bugs" often jump. The person demonstrating this may use a knife blade or metal object to probe an inanimate object they believe to be an insect. If the suspected pest is on a nylon slip of slick fabric, the static electricity developed with this activity may obviously make the object jump. Unfortunately, a simple explanation made to the person in an effort to describe the phenomenon may or may not suffice.

3. The "bugs" may be stated to be infesting the patient's hair, and the person states that the bugs can be shaken or combed into a sheet, towel or newspaper.

4. "Bites" develop on the skin, usually itch, and cause the person to scratchf, even to the point of incurring harsh tissue damage.

5. "Bugs" may come out of such common household items – toothpaste, petroleum jelly or cosmetics.

6. The supposed infestation in a home may becomes so severe as to literally force the person to move to another location. Unfortunately, the "bugs" usually appear in the new dwelling, or the infestation is reported to go from place to place with the person and even infest other individuals.

7. The patient may be so positive of the infestation and provide such a lucid description that the family will stoutly support the conviction, even though not afflicted.

8. The supposed “infestation” may have lasted two or three months or longer. Arthropod infestations actually last this long.

9. One should not let this lead him astray, since there is the possibility that there has been an original and very real arthropod infestation. Such infestations could have receded and may have been the trigger for delusion.

With respect to the pest control operator’s role in handling an entomophobia or delusory parasitosis case, it is first essential that one make a thorough inspection to actually determine the absence of any pests and then to convey this immediately and firmly to the patient. This is needed immediately, so as not to delay medical or psychiatric treatment, and firmly, so as to leave no lingering doubt in the patient’s mind. The definitive inspection should be conducted by the most qualified member of a firm.

Some experts suggest using ingenuity and good IPM techniques in homes or offices where there are complaints about “paper mites” or “invisible biting insects.” It is important to follow the above recommendations for inspecting to rule out minute insects.

Vertebrate Pests

Learning Objectives:

After reading Vertebrate Pests, the trainee should be able to:

- Identify, compare and contrast characteristics of young and adult rats and mice.
- •. Identify a venomous versus non-venomous snake.
- •. List key signs that identify the type of vertebrate pest species that is causing problems.
- •. Describe the best method, or combination of methods, for addressing a particular vertebrate pest problem.
- Know key characteristics of vertebrate pest species as they relate to control techniques. For example, know the behaviors of roof and Norway rats and understand how these behaviors affect bait selection and placement.
- •. Describe the tools (e.g., baits, traps) for administering control techniques for a specific vertebrate pest species.
- Compare the effectiveness of various control techniques for vertebrate pest control.
- Know common names of rodenticides and their classification, types of formulations and safety precautions.
- Know the legal restrictions, if any, for taking vertebrate pest species and the agency or agencies legally responsible for the pest species' management.
- Describe steps of action if bitten by a snake, skunk, bat or other vertebrate pest species.
- Know diseases and health hazards associated with a particular vertebrate pest species.

An animal with a backbone or spinal column is called a vertebrate. Humans, dogs, snakes and birds are examples of vertebrates, while insects, worms and snails are not. A few vertebrates, such as rats and mice, are common pests in urban and industrial sites. Others are not pests in their normal habitats, but may occasionally become pests when they increase in number, pose a health or safety risk or cause property damage. A skunk in the woods is a beneficial part of nature; a skunk denning in the crawlspace of a home is an entirely different matter.

Some vertebrates that are serious pests in particular situations are never considered pests by certain people. Pigeons, for example, can cause human health problems when roosting in large numbers. Commonly, their droppings foul sidewalks, contaminate food and damage automobile paint. But pigeons are seen as pets and friends by those who feed them daily. These constituents react angrily to any attempt to poison or trap pigeons.

People feel a strong attachment towards vertebrates that they do not feel towards other pests. Children in particular love and cherish them. Many people today are involved emotionally in the welfare of animals, particularly domestic pets, and in conserving wildlife. Control of vertebrates, other than rats and mice, can be more of a public relations problem than a pest problem. Killing is the method of last resort and, in some circumstances, is illegal.

Public concern for the welfare of animals and the risk from vertebrate poisons to people, pets and other nontarget animals have made rules governing vertebrate pest control particularly strict. Laws and regulations at the state and local level may be much more restrictive than federal regulations. Be sure you understand all the regulations that apply where you work.

Bats

Arkansas is home to 16 bat species. State law protects all bat species, but the federally endangered Indiana bat (*Myotis sodalis*), gray bat (*Myotis grisescens*) and Ozark big-eared bat (*Corynorhinus townsendii ingens*) receive additional state and federal protection. It is illegal to kill, harm, harass or possess these endangered mammals. Removing bats requires special expertise and skills. The Arkansas Game and Fish Commission periodically offers specialized training on bat removal to pest and nuisance wildlife control operators. For more information, contact the nongame mammal program coordinator at 1-800-364-4263.

Single Bats in Buildings

If a bat enters a home or building, simply turn off the lights and open a few doors or windows leading to the outside, and allow the bat to leave on its own. Chasing or swatting bats causes undue

panic for the flying mammals and people alike. If opening windows and doors doesn't do the trick, the bat can be caught in a butterfly net. Always wear thick leather gloves when netting or capturing a bat. If the bat is resting on a wall or curtain, place a coffee can or large bowl slowly over it while sliding a piece of cardboard between the bat and the wall. The bat should be released in an elevated position such as a tree branch or wall. Unlike birds, bats have to drop and catch air under their wings before they can fly.

Bat Colonies

If a bat colony is in an occupied building, seal entrances into the home's living space. Some people decide to let a small colony remain in attics or under eaves. Additional measures may not be necessary unless bat droppings become a problem, or there is a concern about bats coming into direct contact with people or pets. To remove the bat colony, you will need to develop a plan for excluding bats without trapping them within the structure. For difficult problems, contact the Arkansas Game and Fish Commission's bat biologist for advice.

To clean an attic after relocating a bat colony, sprinkle diatomaceous earth in the roost area to eliminate any parasites that remain. Thoroughly spray bat droppings with water to reduce the amount of dust and prevent spreading spores from *Histoplasma capsulatum* that can cause histoplasmosis. Histoplasmosis is an infectious, non-contagious disease that originates from a fungus that lives in bat and bird droppings. Exposure to this fungus is widespread in Arkansas, although the vast majority of infected people have no ill effects. Some may require medical attention for respiratory problems that develop 3 to 17 days after exposure. If large amounts of bat droppings are to be removed, take precautions against inhaling airborne particles. Use a respirator mask that filters particles of two microns in diameter or smaller. For more information, contact the Arkansas Department of Health or your county Extension office for the publication titled "Histoplasmosis Control" (MP 268).

Bat Control Techniques

The best bat control technique is preventing their entry into the building. Bat-proofing should be conducted in the spring before bats enter the roost or the fall after young bats leave. Bat-proofing should never be attempted from May through August when the youngsters are in the roost. Bat-proofing at this time could lead to health risks and odor problems as the young bats will die and decay, not to mention ethics and the legality of harming and killing bats. Carefully evaluate your situation and develop a strategy, perhaps using several of the bat-proofing techniques described below:

(1) Seal entrances.

With as little as a 3/8-inch wide crack, bats can gain entry through an open window, an unscreened chimney, a gap in an outside wall, roof overhangs, loose vents, openings where electrical wire boxes or water pipes enter the house or openings between drop siding. Once bats are evicted, screen or tape their entrances, plug holes with steel wool or a copper mesh or gauze and fill cracks with expanding foam insulation or caulking. To observe where bats are entering or exiting, station several people around the building so that all sides can be seen about 30 minutes before dark or one hour before dawn. Watch for about an hour, noting where they are flying in or out. If no bats are seen, try another evening when the weather conditions are different. Observers should be as quiet as possible. A flashlight can be used, but direct the main part of the beam away from where bats are exiting, as this may cause them to stay inside the building.

(2) Install one-way doors.

Do **not** use one-way doors from May through August when flightless young bats are present. You can make your own one-way door from heavy plastic, bird netting or wire screening (Figure 7-1). If using plastic or bird netting, make a strip at least 2 feet wide and extend it at least 2 feet below where bats exit. The material should be stapled or taped several inches above the exit. Let the remaining material hang about a foot to each side and below the exit. The bats should have enough space to drop down and exit but unable to fly up and reenter the building. Another alternative is to use 1/4- to 1/2-inch wire screening or plastic mesh to cover the exit. The screening should cover the width of the hole and extend approximately 3 feet below the hole, so the bat can crawl down the screening and exit from the bottom. The screening can be secured to the building with tape or staples. Remove the one-way door after three or four days and seal the opening.

Figure 7-1. One-way doors allow bats to exit a building but prevent their reentry.

(3) Install polypropylene bird netting.

Netting for excluding birds from agricultural crops and fruit trees may be a practical exclusion device in some situations for bats. The netting can be draped over parts of a building in April or May when the bats begin arriving, then removed and stored until the next spring. Check local markets for bat netting products sold in self-contained kits.

(4) Provide alternative housing.

Advise the client to consider installing alternative housing for bats. Once bats are excluded, they have to find somewhere else to live or they will die. In one instance, bats had lived in an attic before bat-proofing began roosting under the eaves near their old exit. A bat box was installed, and the bats took residence in this alternative structure. Ideally, bats should be allowed to investigate a new bat house well in advance of bat-proofing a building in the fall. It is best if a standard bat box can be installed near the bats' entry to the building. Bats are very loyal to traditional roosting sites. By providing a bat box, those returning in the spring may be less inclined to find another entry into the building where they previously roosted.

For more information about bat box design and placement, contact:

- Your local Cooperative Extension Service office (*www.uaex.edu*) and ask for the publication titled "Bats in and Around Your Home" (FSA9088).
- Arkansas Game and Fish Commission's Web site (www.agfc.com) or call (501-223-6300) and order *Woodworking for Wildlife* for other wildlife structures.
- Bat Conservation International (www.batcon.org) is an organization dedicated to preserving bats and their habitats through partnerships with government agencies, research and education. BCI publications include *BATS* magazine, *The Bat House Builder's Handbook* and educators' packages about bats (1-800-538-BATS).
- Contact the Organization for Bat Conservation (517-339-5200, www.batconservation.org) which offers a number of educational materials and information about bats and bat house designs.

Implementing multiple techniques is the best approach to bat-proofing your home. When young bats are not present, seal all but a few bat entrances and install one-way doors in the remaining entrances. This allows bats to leave but not return.

Bats and Rabies

Rabies is the most important public health hazard associated with bats, although the incidence of transmission is very rare. Bat Conservation International reports that more humans die annually from being attacked by domestic dogs than from encounters with bats. Despite this low incidence, a sick bat is a risk for rabies and should be avoided. Sick bats are active during the daytime or are found on the ground and incapable of flying. A bat found on the ground is not necessarily rabid, but don't tempt bats by touching them, as bats are more likely to bite if touched. If bitten or scratched by a bat, wash the affected area with soap and water, and seek immediate medical attention. Try capturing the bat without damaging its head, so that it can be tested for rabies. Modern treatment for rabies is normally safe, relatively painless and very effective. A lack of treatment can result in death, so get prompt treatment after exposure.

Birds

Almost all species of songbirds are federally protected migratory species. It is illegal to destroy the birds, their eggs or nests without federal and sometimes state permits. Exceptions are pigeons, starlings and house sparrows. Although more bird

control methods are available for these species, precautions should be taken to avoid harming nontarget bird species. It is illegal to kill or harm all other songbirds without obtaining appropriate permits. For additional information, contact USDA Wildlife Services office in Little Rock (501-378-5382) or Stuttgart (870-673-1121).

It is important that bird species be identified positively prior to applying a method or technique. Clients may misidentify bird species. “Blackbirds” could refer to red-winged blackbirds, starlings, grackles or brown-headed cowbirds. Some techniques may be illegal for particular species of songbirds. Use a bird field guide, the internet or a local bird expert to identify target and non-target bird species. Pigeons, house sparrows and starlings are three primary pest bird species that will be discussed in this section.

Pigeons

Pigeons, also called rock doves, are gregarious and may congregate in flocks of a hundred or more. They were introduced to the United States as a domesticated bird, but many escaped. They have become the most common bird pest associated with people. Although primarily seed or grain eaters, in urban areas pigeons feed on garbage, spilled grains, insects and food left by outdoor diners and bird lovers who intentionally feed pigeons bread, peanuts and cookie crumbs.

Pigeons feed, roost and loaf in each other’s company whenever possible. Feeding, roosting and loafing sites are usually separate. Roosting sites are protected from the elements and used for nesting, congregating at night and shelter in bad weather. Loafing sites will be nearby to be used by inactive birds during the daytime. Feeding sites may be several miles away. When pigeons are not feeding or mating, most of their day is spent cooing, preening and sun bathing. Sunbathing is most common in the morning of cool days.

Pigeons prefer flat and smooth surfaces on which to rest and feed. Unlike most birds, they will feed from rooftops, regardless of height, because they like open feeding areas that permit a speedy get-away. They also feed on open ground and occasionally on ledges, cooling towers, bridges and signs. Typical feeding sites are parks, squares, food loading docks, garbage areas, railroad sidings, food plants and wherever people eat outdoors.

Starlings

European starlings are black-colored birds often lumped with other “blackbird” species. Adults have light speckles on their feathers in winter. Their feathers turn glossy purplish-black and green in summer. They have a yellow bill from January to June, which is dark at other times. Starlings have relatively short tails and appear somewhat chunky and humpbacked. The wings have a triangular shape when stretched out in flight.

Starlings are pests because of their high numbers. They were brought from Europe and released in New York City in 1890 and 1891 by an individual who wanted the continent to have all of the birds mentioned in Shakespeare’s works. Thousands or tens of thousands can roost at one site. Droppings at the roost site damage car finishes, tarnish buildings, drop on people below and build up to such levels as to become a health hazard. Starlings have been responsible for outbreaks of a number of diseases.

Leaving their evening roost at sunrise, they travel to feeding sites over well-established flight lines. When returning to the roost just before sundown, they “stage” on high perches such as trees, power lines, bridges and towers. The birds may remain on pre-roost sites until after sunset, singing and calling to each other.

House Sparrows

The house sparrow, also called the English sparrow, is a brown, chunky bird 5 to 6 inches long. The male has a distinctive black bib, white cheeks, a chestnut mantle around a gray crown and chestnut upper wing covers. The female and young birds have a gray breast, buffy eye stripe and streaked back. House sparrows were introduced to the United States in the 1850s and can be found all over the continent. They are not to be confused with native sparrows that are slim, brown birds with buff or white streaks. However, rarely do native sparrows cause problems around buildings.

House sparrows can be pests in many situations. Their droppings contaminate stored grain and bulk food. Droppings and feathers make hazardous, unsanitary and smelly wastes inside and outside of buildings, on sidewalks and under roosting sites. The birds cause damage by pecking at rigid foam insulation in buildings. They are a factor in the transmission of a number of diseases, internal parasites and ectoparasites.

Bird Control Techniques

The first step in controlling birds is to conduct a detailed and accurate bird survey. Surveys should be conducted early in the morning, midday and again in the evening to correspond to the different activity periods of birds. The survey should not be limited to information about pest birds; nontarget bird activity is just as important in order to minimize risk to these birds. The survey should investigate:

- What bird species are present?
- How many?
- Are they resident or migrant birds?
- Are they juveniles or adults?
- Are they nesting, feeding, roosting, loafing?
- Where do they eat and drink?
- What is attracting them to the various sites?
- Are the birds causing a health risk?
- Are the birds causing physical damage?
- If dispersed, where would they go?
- If poisoned, where would they die?
- Is there risk to nontarget birds, other wildlife, pets or children?
- What are the legal considerations?
- Could there be public relations problems?
- Is exclusion or habitat modification practical?

Some techniques are effective for a number of bird species, while others may apply to only one or two. Table 7-1 lists selected pest bird species and techniques that can be applied to the particular species. Following is a detailed description of each technique.

Exclusion

Some building designs and conditions lend themselves to bird problems. Flat ledges, overhanging eaves, openings in vents, unscreened windows, wood siding and other attributes make a building an attractive location for roosting, nesting, feeding, and loafing. Modification or repair can exclude birds. Typical solutions include replacing broken windows and screens, eliminating large crevices and blocking openings into vents and roof-top equipment with hardware cloth. Netting, custom-designed sheet

Table 7-1. Pest Bird Species and Control Options

Species	Technique							
	Exclusion	**Habitat Modification**	**Destroy Nests**	**Sticky Repellent**	**Trapping**	**Hand Capture**	**Frightening**	**Shooting**
Pigeon	X	X	X	X	X	X	Avitrol	X
Starling	X	X		X	X		Distress calls, Avitrol	X
House Sparrow	X	X		X	X		Avitrol	X
Crows	Netting	X					Distress calls, Avitrol	In season
Hawks and Owls	Porcupine wires	Eliminate perch sites						By permit only
Swallows	X	Avoid overhanging eaves; slick surfaces discourage nesting	By permit only					
Woodpecker	Netting, place hardware cloth or sheet metal over holes	Treat insect-infested wood siding with insecticide		X	By permit only		Loud noises, e.g., handclapping, toy cap pistol	By permit only

metal or plastic covers, porcupine wires and sticky repellents can keep birds from roosting on ledges, roof edges, window sills, building signs and other surfaces.

- Screen eaves, vents, windows, doors and other openings with 1/4-inch mesh hardware cloth.
- Change the angle of the roosting edge to 45 degrees or more.
- Netting can be used to block access of birds to large roosting areas in structures. Netting is especially useful in buildings where aesthetics are of minor consideration. Plastic nets have replaced metal and fiber nets in bird control. Plastic nets are normally extruded black polypropylene and are made with an ultraviolet inhibitor to reduce UV degradation. Knotted nets are also available. Nets will last two to five years depending on exposure to sunlight.
- Install electrical shocking device. Follow package directions for installing such devices.
- Sometimes birds' flight patterns can be impeded by constructing parallel or gridwire systems.
- Custom-designed covers for ledges, window air conditioning units and roof edges can keep birds from infesting these sites. The high cost of this method usually eliminates this option on large buildings that have extensive roosting sites. But covers are valid options where limited applications will keep birds off selected sites and where aesthetics are an important consideration.
- Attach spikes or "porcupine wires" to roosting sites. Porcupine wires, sharp metal spikes or any similar "bed of nails" can stop birds from roosting on ledges. Vendors offer a number of designs that can be bent around curved objects such as signs, or made of transparent plastic material to improve aesthetics.
    - o Check spikes every 6 months for accumulated debris or nest material. Advise clients to regularly remove falling autumn leaves and other matter that can cover the spikes and reduce their effectiveness.

Habitat Modification

Reduce the availability of food and water. Discourage people from feeding pigeons or other pest birds. Some birds rely on available standing water, and its removal could move the flock elsewhere. Modify roosting sites by severely pruning tree twigs and branches, or removing trees entirely. For woodpeckers, consider treating siding or other locations where woodpeckers are feeding with insecticide for indirect control.

Destroy Nests

Pigeons may be induced to move from an infested site by persistent destruction of nests and eggs. Effectiveness is improved if used in conjunction with other methods. Nest destruction is ineffective against sparrows and starlings. Swallow nests must be destroyed repeatedly and persistently before eggs are present, otherwise federal and state permits are required for nest removal.

- Spray high pressure streams of water from fire fighting equipment or other high pressure water lines. This is the most cost effective method of nest destruction. It not only destroys the nest but eliminates ectoparasites, cleans droppings and feathers from the nest site and harasses roosting birds. Use high-pressure sprays where the high pressure or water will not damage buildings or equipment. Remove all droppings and nest materials from the area.
- To follow a more traditional method when spraying is not safe, use a hook fastened to a long pole to remove the nests.
- When nests are within 20 feet of occupied buildings, treat the immediate nest area with an insecticide to eliminate ectoparasites.
- Destroy nests every two weeks during the spring and summer months until the birds move to other nest sites.

Sticky Repellents

These tacky gels or liquids are designed to be sticky enough to make a bird uncomfortable but not so sticky that the birds is trapped. After a few attempts, the bird stops trying to land on treated surfaces. The active ingredient is polybutene or isopolybutene (the same substances used in some adhesive bandages) or petroleum naphthenic oils.

- When selecting a sticky repellent, read the label and manufacturer's technical information on the effective temperature ranges. Under some conditions, sticky repellents melt and run when exposed to direct sunlight and high temperatures. Others may get too cold and reportedly trap a bird. (Pigeons trapped in sticky repellent led to public scrutiny of a wildlife nuisance control company in a western state, resulting in negative publicity from questioning their ethics and humaneness of this technique.)
- Before applying sticky repellents, clean ledges that are covered by bird droppings, feathers and nest material with a wire brush, paint scraper, high pressure hose or steam cleaning.

- Ensure that surfaces are clean and dry.
- Sticky repellents can stain surfaces to which they are applied. Seal concrete, unpainted wood or brownstone with silicone or other sealant, paint or shellac before applying repellent. (Sticky repellents will be absorbed into porous materials.) If in doubt, first apply a small sample in a less visible area to test for staining.
- Use a caulking gun to apply repellent. The depth of the bead necessary to repel different species of pest birds is roughly as follows: crows and sea gulls, 3/8 inch; pigeons, 1/4 inch; starlings, 1/8 inch; sparrows, 1/16 inch. The caulking gun should be held at an angle of 30 to 45 degrees. Do not over-apply. Some undocumented reports indicate birds may become trapped and die as a result of sticking their bill into the repellent and blocking air passages and/or having feathers stick together. Trapping birds with sticky repellent is an illegal use of this product.
- Apply a straight bead on ledges and roof edges about 1/2 inch from the outer edge, with another bead three inches in from the first or they can be applied in a zigzag or "s" curve. Another option is to combine a straight line 1/2 inch from the outer edge and an "s" curve 3 to 5 inches back. Other patterns may work just as effectively. The pattern of application will depend on the site and personal preference.
- Place breaks in the bead every few feet to avoid trapping rainwater against the building.
- For easy removal and replacement, apply waterproof sticky repellent tape on ledge and roof edges.
- Apply bulk gels with a paint roller, putty knife or bulk caulking gun.
- Apply liquids with a roller, brush or compressed air sprayer to girders, rods, sign supports and rooftops. They can also be used to treat the upper surface of branches in trees and bushes. The repellent should be 1/16 to 1/8 inch thick. Liquid application is not recommended for sites where appearance of the sticky repellent would be undesirable.

Environmental conditions, particularly dust, make a big difference in the effective life of sticky repellents. In an area with no dust, applications can remain effective for a year or more. Some sticky repellents have a liquid coating that is sprayed onto the repellent immediately after application. The liquid dries to a brittle film that protects the material from dust and may improve effectiveness for as long as two to five years.

Trapping

Many types and sizes of pigeon and sparrow traps can be purchased or constructed. Most pigeon trapping programs use large walk-in traps. These can be 4 to 6 feet high and designed to be disassembled and moved. Another common type is a low-profile bob-trap that is about 8 to 24 inches high. Sparrow traps include funnel traps, automatic traps and trigger traps. Funnel traps are commonly used; however, sparrows can escape and need to be checked frequently. For automatic traps, the weight of a feeding sparrow causes an "elevator" to drop and the bird is released into a cage. Without the bird's weight, the counterbalanced elevator springs back into its original position. Trigger traps rely on the bird or an observer tripping a trigger to close the exit.

- The best time to trap pigeons and sparrows is in the winter when their food is less available.

- Set traps in inconspicuous places where pigeons and sparrows commonly roost or feed and where traps are not likely to be vandalized.

- Trap placement is important, and moving an inactive trap just 10 to 15 feet may significantly improve catches.
  - Feeding areas are the best trap sites, but are rarely on the same property as the roosting sites.
  - Roof tops that have water from air conditioning units are often good trapping sites in the summer.

- Birds will need to be coaxed into the trap using bait similar to what they are feeding. Whole corn or sorghum (milo) seeds tend to be best, but other options include wheat, oat groats, millet, popcorn, sunflower seeds, peas, greens, bread or peanuts.
  - For a few days or weeks, scatter small quantities of bait throughout the area to start the birds feeding and determine the best trap sites.
  - Consider leaving the traps propped open for the first few days to allow birds to get accustomed to them.

- After birds are calmly entering the trap, set it. Put bait and water inside the trap and just a handful or so of bait outside the trap. For some types of traps, leave one or two "decoy" birds in the trap to draw in other birds.

- Remove trapped birds often (except for decoys); otherwise untrapped birds may become frightened by the fluttering trapped birds.

- Since birds, particularly pigeons, can fly great distances and find their way home, trapped birds should be humanely destroyed. They can be gassed with calcium cyanide or carbon monoxide, but some experts feel it is simpler and more humane to kill the bird by breaking its neck.

Hand Capture

Sometimes indoor roosting sites can be used as a giant trap. Pigeons often use attics, rooftop elevator houses or empty floors of poorly maintained structures as nest and roost sites. By screening all but one or two entrances, these areas can be made into a giant trap. Late in the evening (after about a two week acclimation period), these last entrances can be closed after the pigeons have settled for the night. The trapped birds can then be captured by hand or with "butterfly" nets.

Frightening

Chemical Toxicant – Avitrol is a poison bait with flock-alarming properties used to control many kinds of birds and is a Restricted Use Pesticide. Within 15 minutes of eating a toxic dose of Avitrol, birds flutter erratically and go into convulsions. They may fly away from the baiting site, fly into windows or "dive bomb" into the ground. Affected birds convulse for an hour or more, and die within a few hours to 15 hours. Therefore, this option is not recommended in urban or residential areas where dead birds can result in public distress and outcry from observing dead or dying birds, or cause secondary poisoning to animals that feed on dead pigeons with Avitrol-treated bait in its crop. Avitrol should be avoided when non-target species such as cardinals, blue jays and doves are feeding on corn. Read the label carefully.

- There are different Avitrol baits for each pest bird species: whole corn for pigeons, smaller grains for sparrows and other birds.
- At most sites, birds must be trained to feed on bait. Place untreated whole corn in numerous piles (1/4 lb each) on flat rooftops, ledges and similar sites in the treatment area about 20 feet apart. Continue feeding untreated corn until about 40 percent of the flock accepts the untreated bait, which could take from three days to three weeks.
- Only a small percentage of the flock (5 to 15 percent) needs to be affected for the remainder of the flock to become frightened by the convulsions and distress of the poisoned birds.
- Mix treated Avitrol whole corn with untreated corn in a ratio ranging from 1:29 (treated: untreated) for killing about 5 percent of the flock up to 1:9 for killing about 15 percent of the flock. The higher the proportion of Avitrol, the better the chance to move the flock quickly. However, this also increases the number and visibility of dead or convulsing birds. Use the ratio that best fits the job.
- Set out about half of the amount used to prebait each day. For example, if 8 pounds of prebait were set out for a flock of about 100 birds, set out about 4 pounds of the Avitrol blended bait.
- One Avitrol application is adequate for most jobs. If pigeons become bait shy, wait about three weeks, then begin a new prebaiting program. If a site has been getting a monthly Avitrol "maintenance" baiting, pigeons can become extremely shy. It may be best to switch to another control method.

Audio Frightening – The use of frightening devices can be extremely effective in reducing concentrations of flocking birds. The keys to success are timing, persistence, organization and diversity. Birds are more likely to leave a new roost site than one they have occupied for a while. Additionally, birds that are preparing for migration will be easier to disperse as their departure time draws near. Useful frightening devices include broadcasted alarm and distress calls, pyrotechnics, exploders and other devices. High-frequency (ultrasonic) sound has not proven effective in repelling birds.

- Recorded alarm and distress calls of birds can be effective for many species of birds with the exception of pigeons. The calls are amplified and broadcast, and the speakers moved periodically to enhance effectiveness. Electronically-produced sounds are usually not as effective as recorded bird calls, but their effectiveness is enhanced when used in combination with recorded calls or other methods.

- Pyrotechnic devices that create noises in the air can be effective in dispersing bird flocks. These devices include 12-gauge exploding shells, fire shell crackers, bangers, screamers and rope firecrackers.
- Automatic LP gas exploders are a source for unattended sound and can be run with a timer. Periodically vary the intervals since birds can become accustomed to explosions at regular intervals.

Combining pyrotechnics with shooting live ammunition is not recommended, as crippled birds may serve as live decoys and, therefore, attract more birds. Additional information and assistance is available from USDA Wildlife Services office in Little Rock (501-378-5382) or Stuttgart (870-673-1121).

Shooting

A possible alternative or supplemental method for eliminating birds is shooting. Large, concentrated flocks of blackbirds (i.e., red-winged blackbirds, starlings, grackles or brown-headed cowbirds) and crows which pose a health hazard or are about to cause damage to personal property, crops, trees, livestock or wildlife may be shot without obtaining a permit. For crows, a statewide hunting season is established annually and a hunting permit may be required. Check with a county Wildlife Officer first before shooting crows. English sparrows, starlings and pigeons are not protected and can be shot at any time. Shooting with air-powered pellet guns, .22 caliber rifles loaded with short-range ammunition or .410 gauge shotguns can eliminate small flocks of pest birds. However, most towns and cities have ordinances prohibiting the discharge of firearms and should be checked before shooting.

- Shoot at night or at dawn in roosting areas.
- A high-powered pellet gun is recommended over other types of firearms because it is relatively accurate, quiet, short-ranged and will not cause structural damage.
- Use care as errant shots can be dangerous.

Health Hazards Associated with Birds

Health risks are often exaggerated. Nevertheless, large populations of roosting birds may present risks of disease to people nearby. The most serious health risks are from disease organisms growing in accumulations of bird droppings, feathers and debris under a roost. If conditions are right, particularly if roosts have been active for years, disease organisms can grow in these rich nutrients. When parasite-infested birds leave roosts or nests to invade buildings, their parasites can bite, irritate or infest people. To be safe, when investigating or cleaning up these areas, wear a disposable mask and protective clothing, including safety glasses, plastic or rubber gloves, coveralls and a cap.

Histoplasmosis

This systemic fungal disease is transmitted to humans by airborne spores from soil contaminated by pigeon and starling droppings, as well as droppings by other birds and bats. The soil under a roost usually has to have been enriched by droppings for three or more years for the disease organism (*Histoplasma capsulatum*) to increase to significant levels.

Most infections are mild and produce either no symptoms or a minor flu-like illness. The disease can, on occasion, lead to high fever, blood abnormalities, pneumonia and even death. An estimated 50 million people have had histoplasmosis or been exposed to it, resulting in 500,000 infections, 5,000 hospitalizations, and 800 deaths. A potentially blinding eye condition, called ocular histoplasmosis syndrome, can result from infection by the disease organism. The central part of the retina becomes inflamed and is damaged as blood vessels grow inside the affected area. An estimated 100,000 people have the rapidly progressive form that can lead to blindness.

Cryptococcosis

This fungus is typically found in accumulations of pigeon droppings in attics, cupolas, ledges, water towers and other roosting and nesting sites. Even when old and dry, bird droppings can be a significant source of infection. Cryptococcosis has been found in as many as 84 percent of samples taken from old roosts. The disease, acquired by inhaling yeast-like vegetative cells, results in two forms. The cutaneous form is characterized by acne-like skin eruptions or ulcers just under the skin. The generalized form begins with a lung infection and spreads to other areas of the body, particularly the central nervous system, and can be fatal.

Ectoparasites

Birds can harbor external parasites that can invade buildings. A long list of mites infest pigeons, but the northern fowl mite and chicken mite are usually the main culprits. Other pigeon ectoparasites that may cause problems inside buildings are the pigeon nest bug (a type of bedbug), various species of biting lice, the pigeon tick and the pigeon fly. Droppings, feathers, food and dead birds under a roosting or loafing area can also breed flies, carpet beetles and other insects.

House Mice

Description

The house mouse is a small, slender rodent that is well adapted to living in people's homes, farms and commercial establishments, as well as in open fields and agriculture lands. House mice are not native to the United States, having arrived with early European settlers. They are one of 19 species of rats, mice and voles that inhabit Arkansas. House mice are prolific. Females can produce as many as 13 litters in a year, averaging between four and seven young per litter.

House mice cause an inestimable amount of damage to foodstuffs and structures, particularly wall and attic insulation, electrical wiring and other building components. House mice contaminate food with their hair, urine and droppings. Additionally, mice and their parasites transmit a number of diseases to humans, including salmonellosis (food poisoning), rickettsialpox, lymphocytic choriomeningitis, leptospirosis, ratbite fever, tapeworms and organisms that cause ringworm.

House mice can be distinguished from young rats by the comparative size of their feet and head. A young rat will have larger hind feet and head in proportion to the body than a house mouse (Figure 7-2).

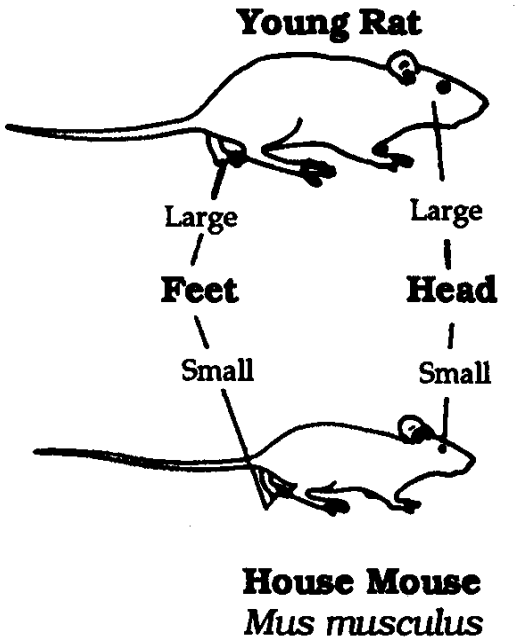


Figure 7-2. House mouse compared to a young rat

Habits and Feeding Behavior

Studies indicate that during its daily activities, a mouse normally travels an area averaging 10 to 30 feet (3 m to 9 m) in diameter. Mice seldom travel farther than this to obtain food. They obtain water from the food they eat. Mice can survive without freestanding water, though they will drink when it's available. A lack of water or food with adequate moisture content can inhibit their population growth. Because of their limited movement and feeding behavior, house mice can be difficult to control in some situations.

House mice eat many types of food but prefer those high in fat, protein or sugar. They relish bacon, chocolate, butter, peanut butter and nutmeats. House mice readily eat new foods. A single mouse eats only about 3 grams of food per day (2.4 pounds per year) but destroys considerably more food than it consumes. Mice have a habit of nibbling on many foods and discarding partially eaten items.

Mouse Signs

There are a number of signs that indicate mice are present in a residence. Mouse **droppings** are 1/4 inch (0.6 cm) long, whereas those of cockroaches are usually 1/8 to 1/4 inch long. Under a magnifying glass, cockroach droppings show distinct longitudinal ridges and squared-off ends. In comparison, mouse droppings are smooth and have tapered or rounded ends. Mouse **tracks** (Figure 7-3) can be seen on dusty surfaces or in mud, or flour can be spread on the floor overnight to determine if rodents are present. **Urine** will fluoresce under ultraviolet light and may occur along travelways or in feeding areas. **Rub marks** may occur on beams, rafters, pipes or walls. They are the result of oil and dirt rubbing off the mouse's fur. **Gnawing** may be visible on doors, ledges, in corners, in walls, on stored materials or other surfaces. Fresh wood shavings or

chewed insulation indicate active infestations. Mouse holes are often 1 1/2 inches (3.8 cm) or less, whereas rat holes are 2 inches (5 cm) or larger. **Sounds** such as gnawing, climbing in walls, running above ceilings and squeaks are common when mice are present. A characteristic musty **odor** is a positive indication that house mice are present. **Visual sightings** can occur during daylight or after dark using a flashlight. **Nests** may be found when cleaning garages, closets, attics, basements and outbuildings. They are constructed of shredded fibrous materials, such as paper or burlap, and appear as a ball of loosely woven material usually 4 to 6 inches (10.2 to 15.2 cm) in diameter.

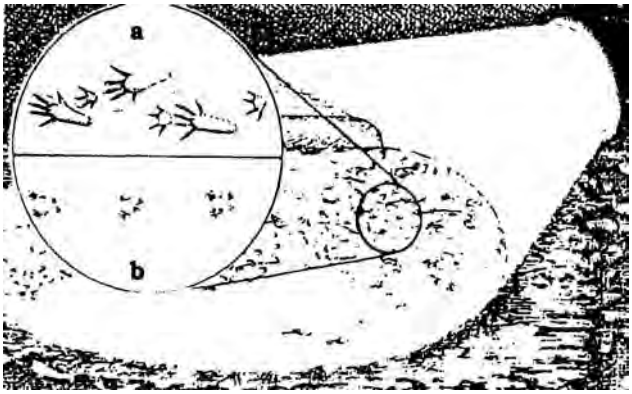


Figure 7-3. Mouse (b) and rat (a) tracks

Mouse Control

The three essential steps for effectively controlling house mice are (1) applying sanitation practices and habitat modification, (2) rodent-proof construction and (3) population reduction. Figure 7-4 (page 81) is a flow chart for determining appropriate techniques for mouse control, based on your particular situation. The techniques recommended in the flow chart are described below.

1. Sanitation and Habitat Modification

Sanitation practices are an effective tool when used in conjunction with rodent-proofing techniques and population reduction methods. Mice can live off a few crumbs or scraps and, therefore, cannot be controlled by good sanitation practices alone. However, good sanitation aids in mice control by (1) permitting easier detection of mouse signs, (2) increasing the effectiveness of traps and baits by reducing alternative food sources and (3) reducing the growth of the mouse population. Good sanitation will seldom eliminate mice; however, poor sanitation will attract mice and permit them to thrive in greater abundance.

Modifying mouse habitat around the home may also help in controlling their numbers and access into the home. Regular removal of debris and control of weeds around homes will reduce shelter available to rodents. Maintaining a clean, 3-foot wide (1 m), weed-free area around building foundations, concrete slabs and footings often discourages rodents from burrowing, as well as eliminating a food source. In some instances, placing a strip of heavy gravel around building foundations will reduce rodent burrows.

2. Rodent-proof Construction

Often ignored, rodent-proof construction is the best defense for preventing problems with house mice. To exclude mice, seal all holes and openings larger than 1/4 inch (0.6 cm) across. Use heavy materials that will withstand rodent gnawing, such as concrete, galvanized sheet metal and heavy-gauge hardware cloth.

To prevent rodent entry, their capabilities need to be understood. Their physical abilities are impressive. Mice can:

- Enter openings larger than 1/4 inch (0.6 cm).
- Run along or climb electrical wires, pipes, fences, poles, ropes, cables, vines, shrubs and trees to gain entry into a building.
- Climb almost any rough vertical surface, including weathered sheet metal and many plastic products.
- Crawl horizontally along or through pipes, augers, conveyors, conduit and underground utility and communications lines.
- Gnaw through a variety of materials including lead, aluminum sheeting, window screens, wood, rubber, vinyl, fiberglass, plastic and low-quality concrete or concrete block.
- Jump as high as 18 inches (46 cm) from a floor onto an elevated surface.
- Travel considerable distances crawling upside-down along screen wire.
- Survive and reproduce at temperatures of 24 degrees F (-4 degrees C) if adequate food and nesting material are available.

When inspecting for potential entryways, look for mouse signs. Pay attention to areas behind, under, or in appliances, sinks, cabinets, drawers, stored goods, wall voids, false ceilings and other undisturbed areas. To conduct a thorough survey, keep a detailed record while inspecting the house of

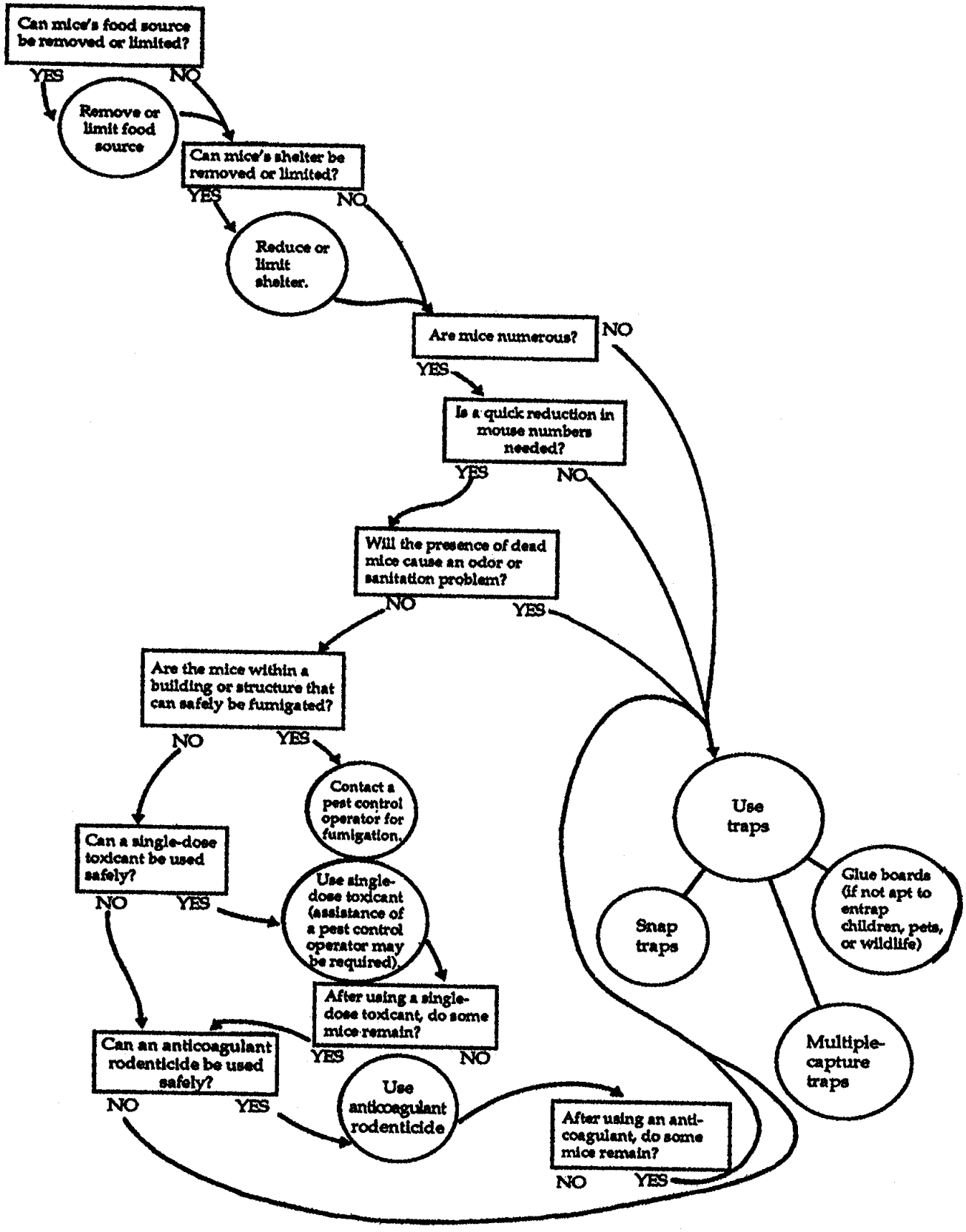


Figure 7-4. A flow chart of steps in house mouse control. Additional factors, such as cost of particular control methods, must be taken into account when planning a control program. Reprinted from "House Mice" in *Prevention and Control of Wildlife Damage* (1994) with permission.

items needing alteration. Bring a pencil or ballpoint pen for keeping records. Also bring a flashlight, mirror (to see under or behind objects), screwdrivers and other tools (to remove interior and exterior vent grills, appliance base plates, attic doors, crawlspaces and utility cabinets), tape measure (for preparing repair materials) and perhaps a camera if leaving the site (for photographing problem areas and designing a solution away from the site).

Mice can enter under doors, through holes beside water pipes and electrical conduit and through the cold air return ducts on forced air furnaces, especially those located in outside cabinets or garages and underneath mobile homes. Mice often find easy access to garage areas through open doors or under poor-fitting garage doors. Once inside the garage, they may gain entry into the main structure along electrical lines, pipes, poorly sealed firewall sheathing, around furnace ducts, hot water heaters or laundry drains.

Pay particular attention to utility entry points, including underground electrical and communication trunk lines, and exhaust vents for cloths dryers. Check all roof joints for tightness and presence of flashing, particularly if mice have access to the roof via wire, pipes, plants or rough-textured walls. Check roof and sewer vents for adequate screening and sealing. Chimneys should be checked for properly installed flashing or missing mortar.

If rodents are able to reach the attic, they may travel from room to room through openings for pipes, ducts and wiring. Inside entry can be achieved through the fireplace, which may have poorly fitted sheeting or metal collars, an open damper or cool air and warm air returns around the fire box. If the outside cannot be sealed, glass doors that seal the burn area are recommended to prevent entry throughout the year.

Gaps in foundations and slabs, or where the wall framing meets the foundation or slab floor, may provide large enough openings for entry. Older buildings commonly have cracked foundations, cracked plaster or mortar, warped siding or broken and torn vent screens. Wood or masonite siding is especially vulnerable to warping and cracking near corners and around the base of the building. Old, unused holes where utilities formerly entered the structure are also common points of entry.

Recommendations for Repair

Holes and openings: For a temporary plug, seal with steel wool, copper gauze or screen wire packed tightly into opening. For a permanent repair, mix a quick-drying patching plaster into a wad of patch material (avoid steel wool, as it will rust) and push the material into the hole. Smooth over the outside so that it will be difficult for a mouse to find a rough edge to gnaw. (The inward curve of a mouse's teeth make it difficult to gnaw into a flat, hard surface. When given a rough surface or an edge to bite into, however, they can quickly gnaw into most materials.)

Holes 3 inches (8 cm) or more in diameter should be covered or backed with 1/4 inch (0.6 cm) woven/welded hardware cloth prior to patching. An alternative is a sheet metal patch with a self-adhesive backing. Close openings around augers, pipes and electric cables using Portland cement mortar, masonry, metal collars or other appropriate product. For large openings, recommended materials are concrete (minimum thickness of 2 inches [5.1 cm] reinforced, or 3 3/4 inches [9.5 cm] if not reinforced), galvanized sheet metal (24 gauge or heavier for wall or pipe barriers, 22 gauge or heavier for kick plates or door edging, 14 gauge for perforated or expanded sheet metal grills), brick (3 3/4 inch [9.5 cm] thick with joints filled with mortar), hardware cloth (woven, 24 gauge, 1/4 x 1/4 inch [0.6 cm x 0.6 cm] mesh), and aluminum (22 gauge for frames and flashing, 18 gauge for kick plates and guards) (Figure 7-5).

Vents and windows: Use only metal window screening materials to prevent mice entry. For large openings or where the screen may be subject to abuse, add crossbars to support the screen.

Vents for heating and air conditioning should be screened if at all possible. To prevent a reduction of airflow, 1/2 x 1/2 inch (1.3 cm x 1.3 cm) hardware cloth is recommended, although a smaller gauge would be more effective for rodent control. Sometimes, power vents can be covered with hinged metal plates (louvered) that open with air flow and close when the fans are off. However, louvers must fit tightly to be effective at preventing mice entry.

Exterior doors: Doors should fit tightly and the threshold not exceed 1/4 inch (0.6 cm). Metal thresholds can be fastened to floors.

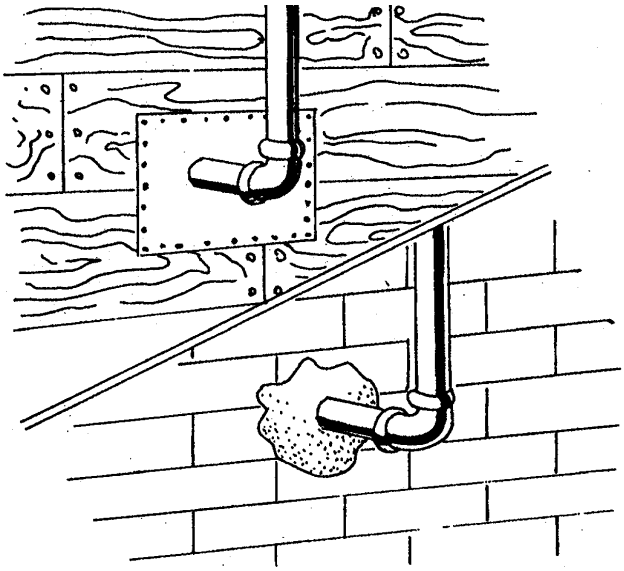


Figure 7-5. Seal holes with rodent-proof materials where pipes, wires or similar objects enter buildings.

Foundations and floors: Gaps or flaws along building exteriors where the wall framing or siding meets the foundation provide easy entry for mice. Such openings can be prevented by well-formed and finished concrete work and installation of tight wall framing and siding, or installing metal screed-type flashing between the siding and the foundation. Metal siding may provide entry points where panel ends are left open. Use of concrete, plaster or metal sheeting is effective if properly installed so that all the ribs or corrugations are closed. Rubber or vinyl weather stops are quickly gnawed through. Repair cracks in foundations and floors with concrete or masonry grout. Note that rodents can claw and gnaw at concrete and Portland cement until it is fully cured, so the use of hardware cloth laid in the top 1/4 inch (0.6 cm) of the repair area may be necessary or provide a rodent-proof overlay until the concrete is fully cured. **Caution:** Metal products placed within one inch (2.5 cm) of a concrete surface will oxidize and corrode and may discolor the concrete.

Drains and pipes: Mice use drainage pipes or sewage systems as routes to enter buildings. Equip floor drains with metal grates held firmly in place, with grate openings not exceeding 1/4 inch (0.6 cm). Maintain 1/2 inch (1.3 cm) hardware cloth over sewer roof vents.

Climbing walls, vertical pipes or electrical wires: Physical barriers and guards can be constructed to prevent mice from climbing up walls or at corners of walls. A sheet metal band attached to a wall at least 26 inches (91 cm) above the floor or ground will prevent mice from climbing (Figure 7-6). This rodent guard should be at least 14 inches (36 cm) but preferably 18 inches (46 cm) wide. A flat guard can be placed on top of a vertical pipe or electrical wire that is attached to a wall. Cone-shaped circular guards can be constructed for placement around free-standing pipes or wires. Use 24-gauge metal and extend the cone out at least 18 inches (46 cm) around the pipe or line. Anchor the cone in place by one or more arms on the side opposite to that accessible to rodents.

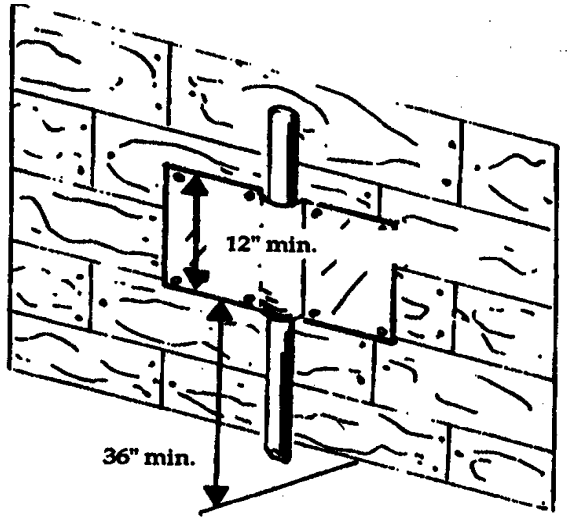


Figure 7-6. Guards of various designs can prevent rodents from climbing along walls, wires or pipes.

3. Population Reduction

Once sanitation practices are in place and rodent-proofing has begun, it is time to concentrate on reducing the number of mice in the home. In homes with moderate or severe infestation, techniques to reduce or eliminate mice won't solve the problem if mice populations outside the home can gain easy entry. The mice outside can repopulate those that are removed from inside the home, thus becoming a never-ending cycle unless rodent-proof measures and sanitation practices are attempted before or simultaneous to population reduction.

House mice populations can be reduced using a variety of traps and baits. Generally, baiting is recommended in cases of severe infestation and a quick reduction of mouse numbers is needed. Trapping is recommended when only a few mice are causing problems and a quick reduction is not necessary. Considerations for other circumstances are described more fully in the flow chart (Figure 7-4).

Trapping – Trapping can be effective for controlling a few mice around homes, garages or small structures. For large mice infestations, trapping requires more labor and is recommended only in situations where poisons cannot be used. Trapping also offers the advantage of being able to dispose of mice carcasses, rather than dealing with problems associated with odors from irretrievable carcasses that decompose after poisoning.

A simple, inexpensive, wood-based snap trap is available in most home and hardware stores and, if set properly, is very effective in killing mice. Set traps close to walls, behind objects, in dark places and in locations where mice activity is observed. Place the trap trigger along the mouse's runway, which is usually along the base of a wall, so that the mouse will pass directly over the trigger. Place the trigger side of the trap closest to the wall, and set another trap beside it to improve your success (Figure 7-7). Another trick is to expand the trigger region by attaching a square of cardboard, metal or screen wire to the bait pan. When placing multiple traps, position them no more than 6 feet apart where mice are active. Bait traps with peanut butter or tie securely a small piece of nutmeat, chocolate candy, bacon or marshmallow to the trigger.

Multiple-capture (automatic) mouse traps are available commercially and from some home and hardware stores. These work on the principle of a one-way door where mice enter but cannot exit and may catch many mice at one location. These can be effective, but must be emptied periodically so that mice do not die of starvation or exposure in the traps. Other types of box traps (e.g., Sherman traps) will capture one mouse at a setting and are typically used for research purposes.

An alternative to traps is glue boards, which catch and hold mice attempting to cross them. Place glue boards wherever mice travel. Do not use glue board where children, pets or other wildlife can contact them. Glue boards are considered by some to be inhumane, as mice attempting to free themselves may struggle for up to several hours. Glue boards lose their effectiveness in dusty areas unless they are covered, for example, with a shoebox having an entry hole at each end. Temperature extremes can also affect the tackiness of some glues.

Baits – The use of toxic baits, i.e., rodenticides, is recommended when there are large infestations of house mice and there is less concern about odors resulting from decomposing carcasses. Whenever a rodenticide is used, safety must be the first consideration. Place toxic baits where inaccessible

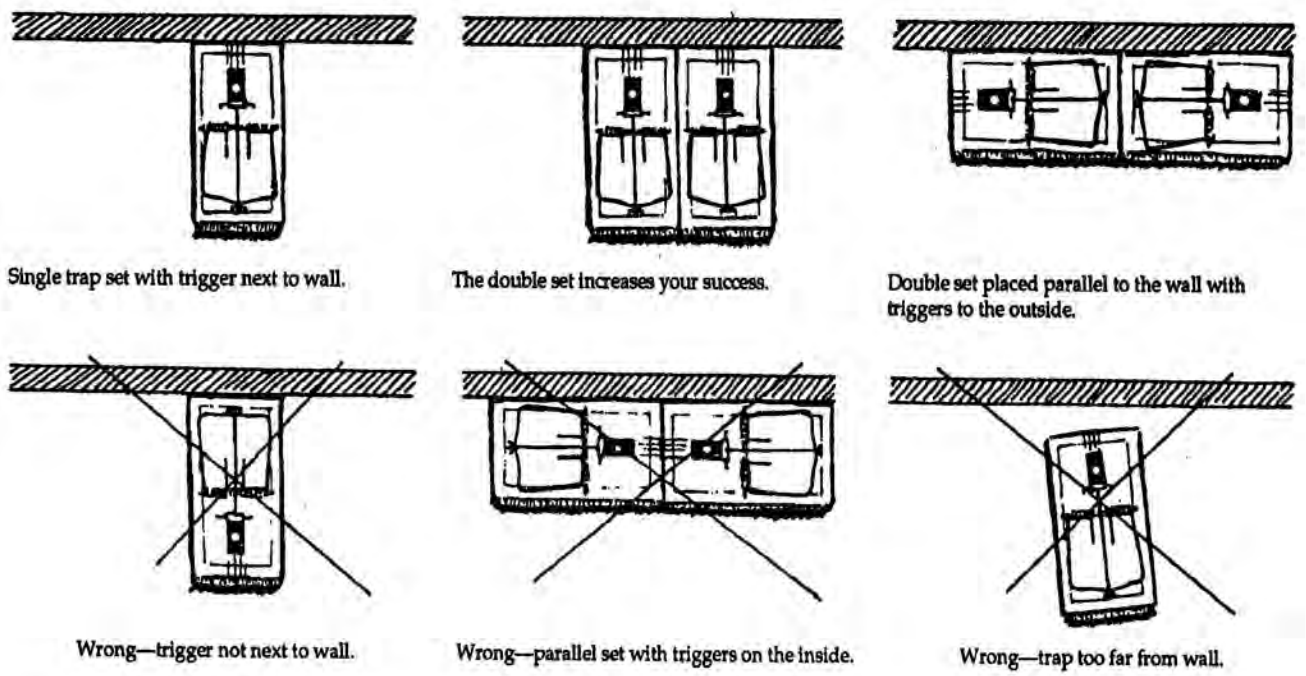


Figure 7-7. Right and wrong ways to set a snap trap. Examples are setting a single trap set with the trigger next to the wall, a perpendicular double set, and a parallel double set with the triggers to the outside.

to children and pets. Mice are color-blind; therefore, dyes that are tasteless to rodents can be used in baits to identify them for reasons of safety.

One classification of rodenticides are anticoagulants (Table 7-2), which are slow-acting, chronic toxicants that require multiple feedings to be effective. Examples of first-generation anticoagulants are warfarin, chlorophacinone and pindone. Second-generation anticoagulants (brodifacoum, bromadiolone and difethialone) can be effective after a single dose, though it may take up to five days before death ensues.

Rodents poisoned with anticoagulants die from bleeding internally. A few cases of pet poisoning have been reported when pets feed on dead rodents. Dogs are more sensitive to antigoagulants than are cats, and pets accustomed to feeding on dry foods can easily ingest a toxic dose of rodenticide if these baits are accessible to them. Older, first-generation anticoagulants (e.g., warfarin, diphacinone, chlorophacinone) are considered less hazardous to pets because they typically require multiple feedings to achieve a lethal dose, and accidental poisoning can be treated with an antidote, Vitamin K_1. However, the majority of anticoagulants being marketed today (including many d-CON products) contain brodifacoum or other second-generation materials than can be fatal in a single feeding.

Label directions on anticoagulants commonly instruct maintenance of a continuous supply of bait for 15 days or longer until feeding ceases. Anticoagulants are purposefully slow-acting to prevent mice from becoming bait-shy. If the bait produces an ill effect in a mouse but not death within a few hours, the bait will often become associated with the illness. Bait shyness can persist for weeks or months and may be transferred to nontoxic foods of similar types.

Bromethalin, cholecalciferol and zinc phosphide are single-dose, non-anticoagulant rodenticides that can be effective for anticoagulant-resistant populations of house mice (Table 7-3). Although only a single dose is required, both bromethalin and cholecalciferol may take up to four days before death ensues. Because of this slow action, the mice's subsequent illness is not associated with the bait even if a sublethal dose is consumed. Bait shyness does not usually occur. These baits, in effect, serve as their own prebait.

Zinc phosphide is relatively quick acting, with results evident one-half to 20 hours after ingestion. Because a mouse could potentially ingest a small amount of zinc phosphide and survive, prebaiting is recommended. Prebaiting, training mice to feed repeatedly on non-toxic bait prior to applying the toxic bait, will encourage mice to feed subsequently on the toxic bait, largely preventing sublethal doses and bait shyness. As with any product mentioned, be sure to follow label recommendations to achieve best success. All single-dose, non-anticoagulant baits should be removed and destroyed at the end of a poisoning program.

Table 7-2. Anticoagulants Used for House Mouse Control

Common name and typical trade names	Chemical name	Usual types of formulations		
		Food bait	Liquid	Tracking powder
Brodifacoum* (Talon®)	3-[3(4'-bromo[1,1' biphenyl]-4-yl-)-1,2,3,4-tetrahydro-1-naphthalenyl]-4-hydroxy-2H-1-benzopyran-2-one	X		
Bromadiolone* (Maki®, Contrac®)	3-[3-(4'-bromo [1,1'biphenyl]-4-yl)-3-hydroxy-1-phenyl-propyl]-4-hydroxy-2H-1-benzopyran-2-one	X		
Chlorophacinone (RoZol®)	2-[(α-chlorophenyl)phenylacetyl]-1,3-indandione	X		X
Difethialone* (Generation®)	[(bromo-4'-[biphenyl-1-1']-yl-4) 3-tetrahydro-1,2,3,4-nathyl-1] 3-hydroxy-4, 2H-1-benzo-thiopyran-2-one	X	X	
Diphacinone (Ramik®, Ditrac®)	2-diphenylacetyl-1,3-indandione	X		X
Warfarin	3- (α-acetonylbenzyl)-4-hydroxycoumarin	X	X	

Single-dose, non-anticoagulant rodenticides work in a variety of ways. Bromethalin depresses the central nervous system and results in paralysis. Cholecalciferol, also called Vitamin D_3, is a calcium releaser that causes too much calcium to be released into the blood, resulting in kidney, liver or heart failure. The advantage of Vitamin D_3 is a minimal risk of secondary poisoning to pets or wildlife that eat poisoned rodents. Zinc phosphide causes gas to enter the circulatory system, resulting in heart paralysis, gastrointestional damage and liver damage. Many formulations of zinc phosphide are Restricted Use and require an applicator's license to be administered.

Ready-to-use baits come in a variety of formulations. Oatmeal, ground or rolled wheat, rolled barley, ground or rolled milo and corn have been successfully used as chief ingredients in toxic baits for house mice. Grain-based baits in loose meal or pelleted form are available in bulk or packaged in small plastic, cellophane or paper "place packs." These packs keep bait fresh and are easy to place in burrows, walls or other locations. Mice will gnaw through the bag to feed on a preferred bait. The disadvantage of bait bags is that they may be moved to places where it is undetected and hazardous to other animals besides mice.

Other bait formulations are available but are more suitable for agricultural or industrial purposes. Bait in wax or extruded blocks can be used in moist areas where grain baits may readily spoil. When no water is present, concentrated baits are available that can be mixed with water and sugar to create a liquid bait for thirsty mice. Neither of these baits, however, is any more effective than grain baits.

Sometimes mice may ingest baits with no results or reject baits altogether. In situations with moderate to severe infestation, check for differences in bait acceptance among several types of bait prior to investing time and money in a specific bait product. Mice may be rejecting a bait product simply because the bait does not taste as good as other available foods. In this instance, reduce the availability of other foods and test different formulations of bait. Other reasons for failure of baits are:

- Too short a period of bait exposure.
- Insufficient bait and insufficient replenishment of bait.
- Too few bait stations and/or too far apart. For mice, stations should be within 6 feet (2 m) of each other in areas where mice are active.
- Mice moving in from untreated areas, e.g., your neighbors.
- Abundance of other food choices.
- Tainted bait – bait has become moldy, rancid, insect-infested or contaminated.

When anticoagulant resistance to the first-generation anticoagulants is suspected or known, try second-generation anticoagulants or another single-dose product. If bait was initially consumed and a few remaining mice are not taking the bait, the best strategy is to switch to a different bait formulation, place baits in different locations and use other control methods such as traps.

To improve safety of bait application, bait stations (bait boxes) are recommended. Stations may provide mice a protected place to feed, allowing them to feel more secure. Bait stations are available commercially or can be made from scrap wood

Table 7-3. Single-dose, Non-anticoagulant Rodenticides Used for House Mouse Control

Common name and typical trade names	Chemical name	Usual types of formulations		
		Food bait	Liquid	Tracking powder
Bromethalin (Assault®, Vengeance®)	N-methyl-2,4-dinitro-N-(2,4,5-tribromophenyl)-6-(trifluoromethyl) benzenamine	X	X	
Chloecalciferol (Vitamin D_3, Quintox®, Rampage®)	9,10-Seocholesta-5,7,10 (19)-trein-3 betaol	X		
Zinc phosphide (Ridall®)	Zinc phosphide	X		X

or other materials. Manufactured bait stations are made of plastic, cardboard or metal and come in a variety of shapes and sizes. Rodent bait stations can be constructed from a length of pipe or placed under a secure board or box. Clearly label all bait stations with "POISON" or "RODENT BAIT – DO NOT TOUCH" or with a similar warning.

Bait stations should be designed with hole entrances 1 to 1 1/2 inches in diameter and large enough to let several mice feed at once. A cigar box about 10 x 6 x 2 inch high with a hole in each end is ideal for mice. Another type of bait station is a flat, 18-inch (or longer) board nailed at an angle between the wall and floor to protect bait from pets and children, yet allow rodents to feed in a sheltered location (Figure 7-8). Alternatively, bait can be placed in a pipe 2 to 3 inches in diameter and at least 18 inches in length. More elaborate bait stations are completely enclosed with hinged lids for convenient inspection and can contain both liquid and solid baits.

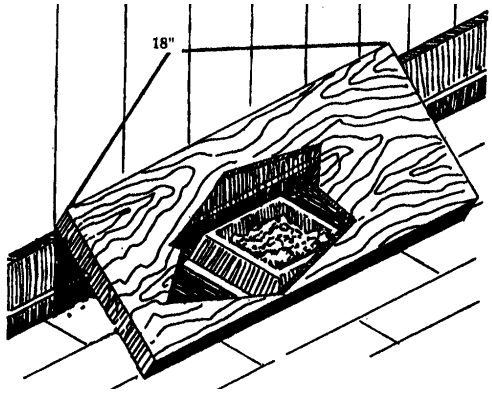


Figure 7-8. A properly designed and placed bait station can help control house mice. In this example, a flat board is nailed to a garage wall to allow rodents to feed in a sheltered location while preventing pets, children and other non-target species from reaching the bait.

Proper placement of bait stations is just as important as using the appropriate bait. Mice will not visit bait stations if they are located in areas with no mouse activity. When possible, place bait stations between the rodents' source of shelter and their food supply. Put bait stations near burrows, against walls or along travel routes. Look for signs of activity such as droppings, gnawings, tracks and rubmarks. Inspect the bait station daily and replenish eaten bait. If bait becomes moldy, musty, soiled or insect-infested, empty the bait station, clean it and refill with fresh bait, as mice will reject soiled or stale bait foods.

Safety Precautions

Certain general safety precautions should be observed in addition to those appearing on labels of specific products.

- Consider all rodenticides dangerous enough to cause death, and place baits where only rodents can get them. No known rodenticides are without some hazard to nontarget animals. Be sure the baits are not accessible to children or pets and other animals.
- People handling baits should neither smoke, eat, drink nor put their hands near their mouths. After preparing or handling baits, wash well, using soap, a brush and plenty of water.
- Whenever possible, buy prepared or ready-to-use baits rather than trying to mix your own. Commercial formulators are governed by regulations that require that operations are safe for their employees. Wear gloves, protective eyewear and a dust mask/mist respirator when handling baits in nonpackaged forms. Clean all bait-mixing utensils thoroughly, and use them only for bait preparation.
- When acute (single-dose) toxicants are used, it may be advisable that each bait placement be recorded. Remove or destroy all uneaten baits at the end of the poisoning period. Only trained individuals should use the more toxic acute-poison baits, even on their own premises. Except for special situations, never leave acute-poison baits exposed for long periods as you would with anticoagulants.
- Tracking powders are a Restricted Use Pesticide and should be used only in limited circumstances. As with any baiting material, certified applicators must wear gloves, protective eyewear and dust/mist respirators when applying tracking powders. Do not place poisonous tracking powders where the rodents might carry them on their feet or bodies to food or food-preparation surfaces. Do not place tracking powders in the vicinity where children, pets and nontarget species frequent.
- During and after a poisoning program, pick up all dead mice. Handle the mouse carcass using rubber gloves or a pair of long tongs.

To dispose of large numbers of dead mice, burn (unless prohibited by law) or bury deep enough not to be dug up by pets or other carnivores. If there are only a few dead mice, place in a plastic bag, close it tightly and dispose with the garbage.

- Label all bait containers or stations, unused baits and rodenticide concentrates with an appropriate warning. Store unused bait away from children, preferably in a locked place. Keep all rodenticides in locked and labeled cabinets. Restrict access to authorized, responsible individuals.

What Isn't Recommended

There are a number of commercial products that are ineffective at controlling house mice populations or are not recommended around homes because of their hazardous nature.

- Frightening devices producing ultrasonic sounds are commercially available, but their effectiveness is unsubstantiated by scientific research. Therefore, these are not recommended as a solution to rodent problems. Loud or unusual noises may temporarily frighten house mice, but mice soon become accustomed to new sounds heard repeatedly.

- Repellents, such as mothballs or household ammonia, may temporarily move mice from one location to another but do nothing to remove the mice. A product called Ro-pel is registered for use in repelling mice from gnawing on trees, poles, fences, garbage and other objects, but will do nothing to remove mice.

- Fumigants typically are not an option in homes. Some fumigants are registered for use in rodent burrows. House mice burrows are often small, difficult to find and cannot be fumigated efficiently or economically.

Tracking powders can be effective at mouse control but are not recommended around homes. When mice walk over a patch of toxic powder, they pick up some on their feet and fur and later ingest it while grooming. Tracking powders are useful in situations where food is plentiful and good bait acceptance is difficult to achieve. The concentration of active ingredient in tracking powders is considerably higher than food baits using the same toxicant. Therefore powders are more hazardous. Many, if not all, are Restricted Use Pesticides.

Concluding Remarks

An effective mouse control program can be achieved through a combination of sanitation practices and habitat modification, rodent-proofing and population reduction. In areas with moderate to severe infestation, a cooperative effort among adjoining properties will be necessary to achieve long-term, effective rodent control measures. Otherwise, mice from surrounding habitats can be expected to "fill the void" and return to the unoccupied rodent habitat in the home. Many commercial products are available for rodent-proofing homes and trapping and baiting mice. Rodenticides (toxic baits) can pose a risk to the handler, children, pets and nontarget wildlife species. Safety considerations should be a priority when implementing these techniques. Because of product turnover, information presented in this chapter may become outdated. Always follow the pesticide label when applying baiting practices.

Moles

Moles are not rodents like mice and rats but are classified as insectivores (insect eaters). Moles search for food and burrow in lawns, meadows, stream banks and open woodlots. They feed on earthworms and insect larvae. Only rarely seen above ground, moles are 4 to 9 inches long, including the tail, with long dark gray or brown fur. Eyes are tiny, like a pinhead, and the tail and feet are usually pink. They have no visible ears.

As they burrow, they sometimes damage plants, but the major problem is the mounds and ridges that disfigure lawns. As they tunnel just below the surface, moles raise the sod up with their digging feet, looking for food or new tunneling sites.

Mole Control Techniques

The most effective method for controlling moles is lethal traps, though this method is also time-consuming. Since moles normally do not consume grain, toxic baits are seldom effective.

To establish which tunnels are active, step down on tunnels in several places in the yard. Mark the tamped area with a peg or wire flag. If the tunnel

has been pushed back up in a day or so, set the trap in that section of the tunnel. Seek a long, straight runway for setting the trap.

Three trap types are harpoon, scissor-jawed and choker loop. The scissor-jawed and choker traps require digging and exposing the tunnel. The jaws or loops are set to encircle the tunnel and are triggered when the mole moves through the trap. The harpoon trap is set directly over the runway, so that the supporting stakes straddle the runway and its spikes go into the runway. The trap is triggered when the mole's tunneling activity causes the soil to strike the pan and trigger the spikes. Set the trigger pan where it just touches the earth where the soil is packed down. Setting the trigger too high or too low will result in misfires. If any of these traps fail to catch a mole after two or three days, move the trap to a new location.

When using traps:

- Place a plastic pail with a warning sign over each trap.
- An average set will require three to five traps per acre.
- Check the trap every day.

Norway and Roof Rats

Description

Norway and roof rats are well adapted to living in people's homes, farms, warehouses, stores and sewers. Both were introduced unintentionally, arriving on ships of early North American settlers.

The Norway rat is also called the brown rat, house rat, barn rat, sewer rat, gray rat or wharf rat (Figure 7-9). The Norway rat is a stocky, burrowing rodent that weighs about 1 pound (454 g) on average. Fur coloration varies from brownish or reddish gray above and whitish gray on the belly, although blackish Norway rats can occur. Their hairless tail is shorter than the head or body. Though they can climb, Norway rats tend to reside closer to the ground or on lower floors of buildings. They may burrow to make nests under buildings, beneath concrete slabs, along stream banks, around ponds, in garbage dumps and other locations where suitable food, water and shelter are present (Figure 7-10).

The roof rat is also called the black rat or ship rat. Fur coloration varies from black with a gray belly, agouti (brownish streaked with gray) back and gray belly, or agouti back and white belly.

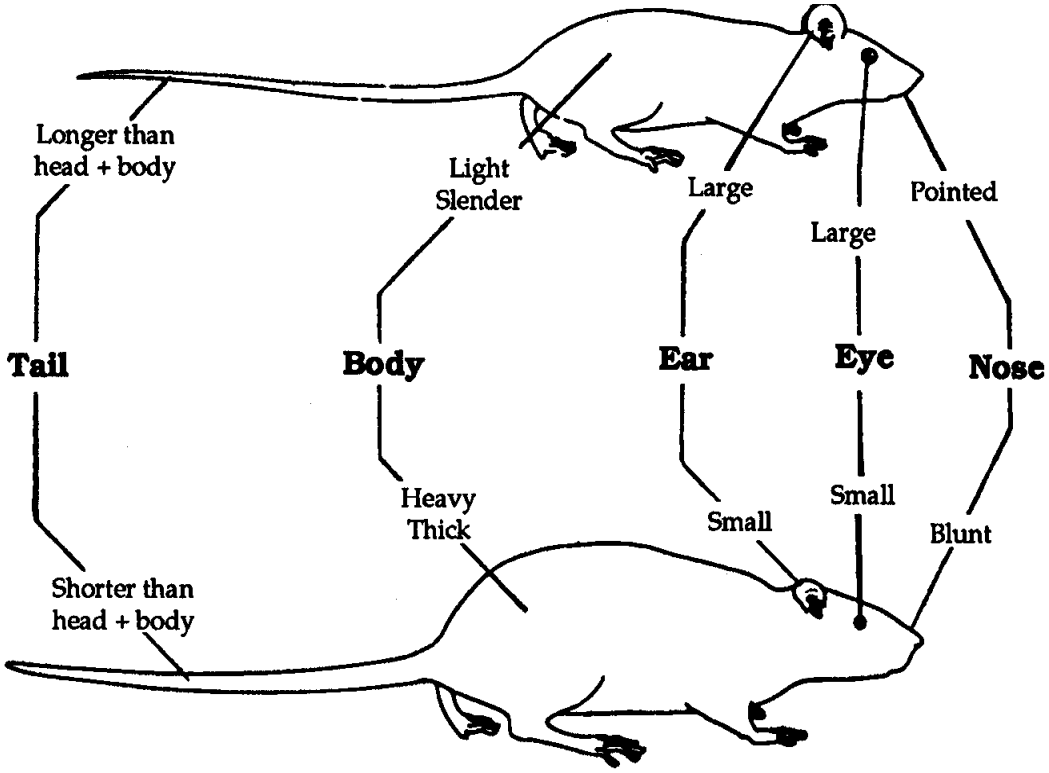


Figure 7-9. Distinguishing characteristics of Norway versus roof rats, and a young rat versus a house mouse

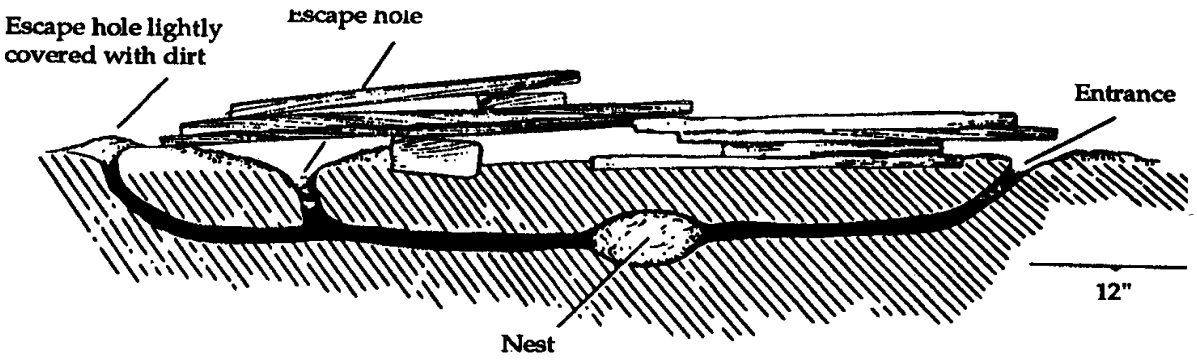


Figure 7-10. Burrowing system of a Norway rat. Burrows are typically 2 to 2 1/2 inches in diameter.

Compared to Norway rats, roof rats are more sleek and graceful, and generally not as large. Their belly fur is uniformly white, buff or gray compared to Norway rats, whose belly fur is white with gray underfur. Roof rats have a pointed muzzle, larger ears and a tail that is longer than their body. Roof rats are more aerial than Norway rats in their habitat selection and often live in trees or vine-covered fences. Unlike Norway rats, roof rats prefer to nest off the ground and rarely dig burrows for living quarters. Roof rats frequently enter buildings from the roof or overhead utility lines. They tend to inhabit upper floors, while Norway rats occupy the first or basement floors. Occasionally, they may live in sewer systems.

Rats consume and contaminate foodstuffs and animal feed, as well as damage the containers and packaging materials where stored. Rats cause structural damage to buildings by burrowing and gnawing. They undermine building foundations and slabs, gnaw on electrical wires or water pipes and chew openings through doors, window sills, walls, ceilings and floors. Considerable damage to insulated structures can result from rats burrowing and nesting in walls and attics. Rats may transmit several diseases to people, including murine typhus, leptospirosis, trichinosis, salmonellosis and ratbite fever. Roof rats are more commonly associated with the plague than Norway rats.

Rat populations can expand rapidly, making them difficult to control. Females can produce 6 to 12 young in 21 days, and sexual maturity is reached at three months. The average female rat has four to six litters annually.

Habits and Feeding Behavior

Rats prefer fresh, wholesome items over stale or contaminated foods. They use their keen sense of smell to locate food items and can taste contaminants as low as 0.5 parts per million. Rats eat cereal grains, meats, fish, nuts and some types of fruits. Roof rats do very well consuming dog or cat food. One rat can eat about a half a pound (227 g) per week, and probably contaminate 10 times that amount with its urine and droppings. Many rat species hoard considerable amounts of solid food in attics, wood piles or behind boxes in a garage, which they find and eat later. They require 1/2 to 1 ounce (15 to 30 ml) of water daily when feeding on dry foods, but need less water when moist foods are consumed.

Rats are primarily nocturnal, though some may be active during daylight when rat populations are high. Studies indicate that a Norway rat normally travels an area averaging 100 to 150 feet (30 to 45 m) in diameter, seldom traveling more than 300 feet (100 m) from a burrow to obtain water. Roof rats will travel 100 to 300 feet (30 to 90 m) for food, and can be seen at night running along overhead utility lines or fences. While rats constantly explore and learn about their environment – memorizing the locations of pathways, obstacles, food, water, shelter and other elements in their territory – they quickly detect and avoid new objects, such as a trap or bait, placed in their environment.

Rat Signs

There are a number of signs that indicate rats are present in a residence. Rat **droppings** may be as large as 3/4 inch (2 cm) long and 1/4 inch (0.6 cm) in diameter. Rat **tracks** (see Figure 7-3) can be seen on dusty surfaces or in mud or in flour spread on the floor overnight to determine if rodents are present. **Urine** will fluoresce under ultraviolet light and may occur along travelways or in feeding areas. **Runs or burrows** may be found next to walls, along fences, next to buildings or under bushes and

debris. **Smudge or rub marks** may occur on beams, rafters, pipes or walls, as a result of oil and dirt rubbing off the rat's fur. **Gnawing** may be visible on doors, ledges, in corners, in walls, on stored materials or other surfaces. Fresh wood shavings or chewed insulation indicate active infestations. Mouse holes are often 1 1/2 inches (3.8 cm) or less, whereas rat holes are 2 inches (5 cm) or larger. **Sounds** such as gnawing, climbing in walls, running above ceilings and squeaks are common when rats are active.

Rat Control

The three essential steps for effectively controlling rats are (1) applying sanitation practices and habitat modification, (2) rodent-proof construction and (3) population reduction.

(1) Sanitation and Habitat Modification

Sanitation plays an important role in controlling rats. Studies indicate that poor sanitation is one of the basic reasons that moderate to high rat populations flourish in urban and suburban areas. Sanitation involves good housekeeping, including proper storage and handling of food, feed and edible garbage. Pet foods are often a food source for rats in and around homes. Store in metal, rodent-proof materials, and feed pets only what they will consume at a single feeding. Garbage and rubbish from homes, restaurants and other such sources should be properly stored and disposed. A proper refuse storage container is heavy-duty, metal, rust-resistant and equipped with a tight-fitting lid. Containers should be set on racks or stands to prevent rusting, minimize the chance of being overturned and reduce rat shelter under containers.

Regular removal of debris and control of weeds around homes will reduce shelter available to rodents. Eliminate vines growing on buildings and overhanging tree limbs that roof rats may use as travel routes. In some instances, placing a strip of heavy gravel around building foundations will reduce rodent burrows. Gravel should be at least 1 inch (2.5 cm) in diameter and placed in a band at least 2 feet (0.6 m) wide and 1/2 foot (15 cm) deep. Keep the perimeter clean of debris, including stacked firewood and other materials.

(2) Rodent-proof Construction

Often ignored, rodent-proof construction is the best defense for preventing problems with rats. To exclude rats, seal all holes and openings larger than 1/2 inch (1.3 cm) across. Use heavy materials that will withstand rodent gnawing – concrete, galvanized sheet metal and heavy-gauge hardware cloth.

To prevent rodent entry, their capabilities need to be understood. Their physical abilities are impressive. Rats can:

- Enter openings larger than 1/2 inch (1.3 cm).
- Run along or climb electrical wires, pipes, fences, poles, ropes, cables, vines, shrubs and trees to gain entry into a building.
- Climb almost any rough vertical surface, including weathered sheet metal and many plastic products.
- Crawl horizontally along or through pipes, augers, conveyors, conduit and underground utility and communications lines.
- Gnaw through a variety of materials including lead, aluminum sheeting, window screens, wood, rubber, vinyl, fiberglass, plastic and low-quality concrete or concrete block.
- Jump as high as 36 inches (91 cm) vertically and as far as 48 inches horizontally.
- Drop 50 feet (15 m) without being seriously injured.
- Burrow straight down into the ground for at least 36 inches (91 cm).
- Travel considerable distances crawling upside-down along screen wire.
- Reach as high or wide as 13 inches (33 cm).
- Swim as far as 1/2 mile (800 m) in open water, dive through water traps in plumbing and travel in sewer lines against substantial current.

When inspecting for potential entryways, look for rat signs. Pay attention to areas behind, under or in appliances, sinks, cabinets, drawers, stored goods, wall voids, false ceilings and other undisturbed areas. To conduct a thorough survey, keep a detailed record of items needing alteration while inspecting the house. Bring a pencil or ballpoint pen for keeping records. Also bring a flashlight, mirror (to see under or behind objects), screwdrivers and other tools (to remove interior and exterior vent grills, appliance base plates, attic doors, crawlspaces and utility cabinets), tape measure (for preparing repair materials) and perhaps a camera if leaving the site (for photographing problem areas and designing a solution away from the site).

Pay particular attention to utility entry points including aerial (roof rats) and underground (Norway rats) electrical and communication trunk lines and exhaust vents for clothes dryers. Powerlines are a favorite travel route for rodents, especially for roof rats. Rat guards can be attached to overhead utility wires; however, these need to be checked periodically because rats may fray the insulation and cause short circuits. Check all roof joints for tightness and presence of flashing, particularly if rats have access to the roof via wire, pipes, plants or rough-textured walls. Also, check roof and sewer vents for adequate screening and sealing. Chimneys should be checked for properly installed flashing or missing mortar.

In areas with high rat populations, both species can enter buildings through toilets and uncovered drains. A "rat guard" one-way flap can be installed in toilets to prevent entry. Rats often find easy access to garage areas through open doors or under poor-fitting garage doors. Once inside the garage, they may gain entry into the main structure along electrical lines, pipes, poorly sealed firewall sheathing, around furnace ducts, hot water heaters or laundry drains.

If rodents are able to reach the attic, they may travel from room to room through openings for pipes, ducts and wiring. Also, inside entry can be achieved through the fireplace, which may have poorly fitted sheeting or metal collars, an open damper or cool air and warm air returns around the firebox. If the outside cannot be sealed, glass doors that seal the burn area are recommended to prevent entry throughout the year.

Gaps in foundations and slabs, or where the wall framing meets the foundation or slab floor, may provide large enough openings for entry. Older buildings commonly have cracked foundations, cracked plaster or mortar, warped siding or broken and torn vent screens. Wood or masonite siding is especially vulnerable to warping and cracking near corners and around the base of the building. Old, unused holes where utilities formerly entered the structure are also common points of entry.

Dense shrubbery, vine-covered trees and fences and vine ground cover make ideal habitat for roof rats. Severe pruning and/or removal of certain ornamentals is often required to obtain lasting rat control. Remove preharvest fruits or nuts that drop in backyards. Collect and remove all unwanted fruit when harvest is over.

Recommendations for Repair

Holes and openings: For a temporary plug, seal with steel wool, copper gauze or screen wire packed tightly into opening. For a permanent repair, mix a quick-drying patching plaster into a wad of patch material (avoid steel wool, as it will rust) and push the material into the hole. Smooth over the outside so that it will be difficult for a rat to find a rough edge to gnaw. (The inward curve of a rodent's teeth make it difficult to gnaw into a flat, hard surface. When given a rough surface or an edge to bite into, however, they can quickly gnaw into most materials.)

Holes 3 inches (8 cm) or more in diameter should be covered or backed with 1/4 inch (0.6 cm) woven/welded hardware cloth prior to patching. An alternative is a sheet metal patch with a self-adhesive backing. Close openings around augers, pipes and electric cables using Portland cement mortar, masonry, metal collars or other appropriate product. For large openings, recommended materials are concrete (minimum thickness of 2 inches [5.1 cm] reinforced, or 3 3/4 inches [9.5 cm] if not reinforced), galvanized sheet metal (24 gauge or heavier for wall or pipe barriers, 22 gauge or heavier for kick plates or door edging, 14 gauge for perforated or expanded sheet metal grills), brick (3 3/4 inch [9.5 cm] thick with joints filled with mortar), hardware cloth (woven, 24 gauge, 1/4- x 1/4-inch [0.6 cm x 0.6 cm] mesh) and aluminum (22 gauge for frames and flashing, 18 gauge for kick plates and guards).

Vents and windows: Use only metal window screening materials to prevent entry. For large openings or where the screen may be subject to abuse, add crossbars to support the screen.

Vents for heating and air conditioning should be screened if at all possible. To prevent a reduction of airflow, 1/2 x 1/2 inch (1.3 cm x 1.3 cm) hardware cloth is recommended. Sometimes, power vents can be covered with hinged metal plates (louvered) that open with air flow and close when the fans are off. However, louvers must fit tightly to be effective at preventing entry.

Exterior doors: Doors should fit tightly and the threshold not exceed 1/4 inch (0.6 cm). Metal thresholds can be fastened to floors.

Foundations and floors: Gaps or flaws along building exteriors where the wall framing or siding meets the foundation provide easy entry for rats.

Such openings can be prevented by well-formed and finished concrete work and installation of tight wall framing and siding or installing metal screed-type flashing between the siding and the foundation. Metal siding may provide entry points where panel ends are left open. Use of concrete, plaster or metal sheeting is effective if properly installed so that all the ribs or corrugations are closed. Rubber or vinyl weather stops are quickly gnawed through. Repair cracks in foundations and floors with concrete or masonry grout. Note that rodents can claw and gnaw at concrete and Portland cement until it is fully cured, so the use of hardware cloth laid in the top 1/4 inch (0.6 cm) of the repair area may be necessary or provide a rodent-proof overlay until the concrete is fully cured. **Caution:** Metal products placed within 1 inch (2.5 cm) of a concrete surface will oxidize and corrode and may discolor the concrete.

Drains and pipes: Rats use drainage pipes or sewage systems as routes to enter buildings. Equip floor drains with metal grates held firmly in place, with grate openings not exceeding 1/4 inch (0.6 cm). Maintain 1/2 inch (1.3 cm) hardware cloth over sewer roof vents.

Climbing walls, vertical pipes or electrical wires: Physical barriers and guards can be constructed to prevent rats from climbing up walls or at corners of walls. A sheet metal band attached to a wall at least 26 inches (91 cm) above the floor or ground will prevent rats from climbing (see Figure 7-6). This rodent guard should be at least 14 inches (36 cm) but preferably 18 inches (46 cm) wide. A flat guard can be placed on top of a vertical pipe or electrical wire that is attached to a wall. Cone-shaped circular guards can be constructed for placement around free-standing pipes or wires. Use 24-gauge metal and extend the cone out at least 18 inches (46 cm) around the pipe or line. Anchor the cone in place by one or more arms on the side opposite to that accessible to rodents.

(3) Population Reduction

The adaptability of rats to human-created environments and their high fertility rate make for quick recuperation of their populations. Population reduction efforts must reduce numbers to a very low level. Otherwise, rats will not only reproduce rapidly, but can quickly exceed their former density for a short period of time. Unless the rat's living environment is destroyed by habitat modification, improved sanitation and rat proofing, control methods must be unrelenting to be effective.

Trapping is recommended when only a few rats are causing problems. For moderate to severe infestations, a variety of rodenticides are available commercially. The capability of rats to memorize objects in their environment presents a special challenge when introducing traps or baits. Roof rats have a stronger tendency than Norway rats to avoid new objects in their environment. For either rat species, it may take several days before they will approach a trap or bait station. Roof rats may even modify their travel routes and feeding locations; therefore, habitat modifications should be made only after the rat population is under control.

Trapping

Trapping can be effective for controlling a few rats around houses, garages or small structures, but requires more skill and labor than other methods. Trapping is recommended when poison baits cannot be used. It also offers the advantage of being able to dispose of rat carcasses, rather than dealing with problems associated with odors from irretrievable carcasses that decompose after poisoning.

A simple, inexpensive, wood-based snap trap is available in most home and hardware stores and, if set properly, is very effective in killing rats. For Norway rats, set traps close to walls, behind objects, in dark places and in locations where rat activity is observed. For roof rats, traps will need to be placed at the very points that rats traverse in attics or along rafters or ledges. Place the trap trigger along the runway so that the rat will pass directly over the trigger. If along a wall, place the trigger side of the trap closest to the wall, and set another trap beside it to improve your success (see Figure 7-7). Another trick is to expand the trigger region by attaching a square of cardboard, metal or screen wire to the bait pan. When placing multiple traps, position them no more than 6 feet apart where rats are active. Bait traps with a small sample of peanut butter, raisin, prune, gumdrop, marshmallow, hot dog, bacon or nutmeat tied securely to the trigger.

Wire-mesh, live traps are available commercially for trapping rats. Rats that are captured should be humanely destroyed and not released elsewhere because of their role in disease transmission, damage potential and detrimental effect on native wildlife.

An alternative to traps is glue boards, which catch and hold rats attempting to cross them. Place glue boards wherever rats travel. Generally, glue

boards are less effective for rats than mice. They are also more difficult to place where roof rats are active compared to Norway rats. Do not use glue board where children, pets or other wildlife can contact them. Glue boards are considered by some to be inhumane, as rats attempting to free themselves may struggle for several hours. Glue boards lose their effectiveness in dusty areas unless they are covered, for example, with a shoebox having an entry hole at each end. Temperature extremes can also affect the tackiness of some glues.

Baits

The use of toxic baits, i.e., rodenticides, is recommended when there are large infestations of rats and there is less concern about odors resulting from decomposing carcasses. Whenever a rodenticide is used, safety must be the first consideration. Toxic baits should be placed where they are inaccessible to children and pets. Rats are color-blind; therefore, dyes that are tasteless to rodents can be used in baits to identify them for reasons of safety.

One classification of rodenticides are anticoagulants (Table 7-4), which are slow-acting, chronic toxicants that require multiple feedings to be effective. Examples of first-generation anticoagulants are warfarin and chlorophacinone. Second-generation anticoagulants (brodifacoum, bromadiolone and difethialone) can be effective after a single dose, though it may take up to five days before death ensues. Roof rats generally require a few more feedings of first-generation anticoagulants than Norway rats to produce death. However, little difference is evident when using second generation anticoagulants.

Rodents poisoned with anticoagulants die from bleeding internally. A few cases of pet poisoning have been reported when pets feed on dead rodents. Dogs are more sensitive to anticoagulants than are cats, and pets accustomed to feeding on dry foods can easily ingest a toxic dose of rodenticide if these baits are accessible to them. Older, first-generation anticoagulants (e.g., warfarin, diphacinone, chlorophacinone) are considered less hazardous to pets because they typically require multiple feedings to achieve a lethal dose, and accidental poisoning can be treated with an antidote, Vitamin K_1. However, the majority of anticoagulants being marketed today (including many d-CON products) contain brodifacoum or other second-generation materials than can be fatal in a single feeding.

Label directions on anticoagulants commonly instruct maintenance of a continuous supply of bait for 15 days or longer until feeding ceases. Anticoagulants are purposefully slow-acting to prevent rats from becoming bait-shy. If the bait produces an ill effect in a rat but not death within a few hours, the bait will often become associated with the

Table 7-4. Anticoagulants Used for Rat Control

Common Name and Typical Trade Names	Chemical Name	Usual Types of Formulations		
		Food bait	Liquid	Tracking powder
Brodifacoum* (Talon®)	3-[3(4'-bromo[1,1' biphenyl]-4-yl-)-1,2,3,4-tetrahydro-1-naphthalenyl]-4-hydroxy-2H-1-benzopyran-2-one	X		
Bromadiolone* (Maki®, Contrac®)	3-[3-(4'-bromo [1,1'biphenyl]-4-yl)-3-hydroxy-1-phenylpropyl]-4-hydroxy-2H-1-benzopyran-2-one	X		
Chlorophacinone (RoZol®)	2-[(α-chlorophenyl)phenylacetyl]-1,3-indandione	X		X
Difethialone* (Generation®)	[(bromo-4'-[biphenyl-1-1']-yl-4) 3-tetrahydro-1,2,3,4-nathyl-1] 3-hydroxy-4, 2H-1-benzo-thiopyran-2-one	X	X	
Diphacinone (Ramik®, Ditrac®)	2-diphenylacetyl-1,3-indandione	X		X
Warfarin	3-(α-acetonylbenzyl)-4-hydroxycoumarin	X	X	

*This product is capable of being lethal in a single feeding.

Table 7-5. Single-dose, Non-anticoagulant Rodenticides Used for Rat Control				
		Usual Types of Formulations		
Common Name and Typical Trade Names	Chemical Name	Food bait	Liquid	Tracking powder
Bromethalin (Assault®, Vengeance®)	N-methyl-2,4-dinitro-N-(2,4,5-tribromophenyl)-6-(trifluoromethyl) benzenamine	X	X	
Chloecalciferol (Vitamin D_3, Quintox®, Rampage®)	9,10-Seocholesta-5,7,10 (19)-trein-3 betaol	X		
Zinc phosphide (Ridall®)	Zinc phosphide	X		X

illness. Bait shyness can persist for weeks or months and may be transferred to nontoxic foods of similar types.

Bromethalin, cholecalciferol and zinc phosphide are single-dose, non-anticoagulant rodenticides that can be effective for anticoagulant-resistant populations of rats (Table 7-5). Although only a single dose is required, both bromethalin and cholecalciferol may take up to four days before death ensues. Because of this slow action, the rat's subsequent illness is not associated with the bait even if a sublethal dose is consumed; thus, bait shyness does not usually occur. These baits, in effect, serve as their own prebait.

Zinc phosphide is relatively quick acting, with results evident one-half to 20 hours after ingestion. Because a rat could potentially ingest a small amount of zinc phosphide and survive, prebaiting is recommended. Prebaiting, that is, training rats to feed repeatedly on non-toxic bait prior to applying the toxic bait, will encourage rats to feed subsequently on the toxic bait, thus largely preventing sublethal doses and thus bait shyness. As with any product mentioned, be sure to follow label recommendations to achieve best success. All single dose, non-anticoagulant baits should be removed and destroyed after the end of a poisoning program.

Single-dose, non-anticoagulant rodenticides work in a variety of ways. Bromethalin depresses the central nervous system and results in paralysis. Cholecalciferol, also called Vitamin D_3, is a calcium releaser that causes too much calcium to be released into the blood, resulting in kidney, liver or heart failure. The advantage of Vitamin D_3 is a minimal risk of secondary poisoning to pets or wildlife that eat poisoned rodents. Zinc phosphide causes gas to enter the circulatory system, resulting in heart paralysis, gastrointestional damage and liver damage. Many formulations of zinc phosphide are Restricted Use and therefore require an applicator's license to be administered.

Ready-to-use baits come in a variety of formulations. Usually corn, oats, wheat, or barley are the grains that rats prefer. Grain-based baits in loose meal or pelleted form are available in bulk or packaged in small plastic, cellophane or paper "place packs." These packs keep bait fresh and are easy to place in burrows, walls or other locations. Rats will gnaw through the bag to feed on a preferred bait. The disadvantage of bait bags is that they may be moved to places where it is undetected and hazardous to other animals besides rats.

Other bait formulations are available. Bait in wax or extruded blocks can be used in moist areas, such as sewers, where grain baits may readily spoil. Rats accept paraffin block baits less readily than loose or pelleted grain baits, but acceptance of bait blocks is still high. Bait blocks tend to be more effective for roof rats where they can be easily placed in small areas and difficult-to-reach locations. Where label instructions permit, small blocks can be fastened on rafters, ledges or tree limbs where they are accessible to roof rats.

When no water is present, concentrated baits are available that can be mixed with water and sugar to create a liquid bait for thirsty rats. Since rats require water daily, they can be drawn to water stations when other water sources are absent. Rodents are more likely to detect anticoagulants in water baits; therefore, up to 5 percent sugar is sometimes added to liquid baits. Since water is attractive to most animals, use water baits in ways that prevent nontarget animals from drinking them.

Contrary to popular belief, rats prefer fresh, high-quality foods and will reject spoiled or inferior foods. In situations with moderate to severe infestation, check for differences in bait acceptance among several types of bait prior to investing time and money in a specific bait product. Rats may be rejecting a bait product simply because the bait does

not taste as good as other available foods. In this instance, test different nontoxic baits by placing about 4 ounces (115g) of each about one foot (30 cm) apart in several locations where rats are present. Check baits the next few days, keeping in mind that rats are suspicious of new objects and novel foods. They may not accept a new bait until the third or fourth day.

Besides bait acceptance, other reasons for failure of baits are:

- Too short a period of bait exposure.
- Insufficient bait and insufficient replenishment of bait.
- Too few bait stations and/or too far apart. In some situations, stations may have to be within 20 to 30 feet (7 to 10 m) of one another.
- Rats moving in from untreated areas, e.g., the neighbors.
- Improperly placed bait stations. Other foods are more convenient to rats.
- Abundance of other food choices.
- Tainted bait – bait has become moldy, rancid, insect-infested or contaminated.

Sometimes rats ingest baits with no results. Although unlikely, genetic resistance to anticoagulant baits can occur. This may be the case if about the same amount of bait is taken daily for a number of weeks, indicating that the rat population is not declining. In this case, switch to a non-anticoagulant rodenticide. If bait was initially consumed and a few remaining rats are not taking the bait, the best strategy is to switch to a different bait formulation, place baits in different locations and use other control methods such as traps.

Bait stations (bait boxes) are recommended to improve safety of rodenticides from being consumed by non-target animal species and children, protect bait from moisture and dust, provide a protective, attractive place for rodents to feed, allow placement in locations where it might be otherwise difficult and help prevent accidental spilling of bait. Bait stations are available commercially or can be made from scrap wood or other materials. Manufactured bait stations are made of plastic, cardboard or metal and come in a variety of shapes and sizes. Rodent bait stations can be constructed from a length of pipe or placed under a secure board or box. Clearly label all bait stations with “POISON” or “RODENT BAIT – DO NOT TOUCH” or with a similar warning.

Bait stations should be designed with two hole entrances 2 1/2 inches in diameter on opposite sides of the station, so that rodents can see an alternate escape route. A simple bait station is a flat, 18-inch (46 cm) or longer board nailed at an angle between the wall and floor to protect bait from pets and children, yet allow rodents to feed in a sheltered location. Alternatively, bait can be placed in a pipe of 3 1/2 to 6 inches (9 to 15 cm) in diameter and at least 18 inches in length. More elaborate bait stations are completely enclosed with hinged lids for convenient inspection and can contain both liquid and solid baits (Figure 7-11).

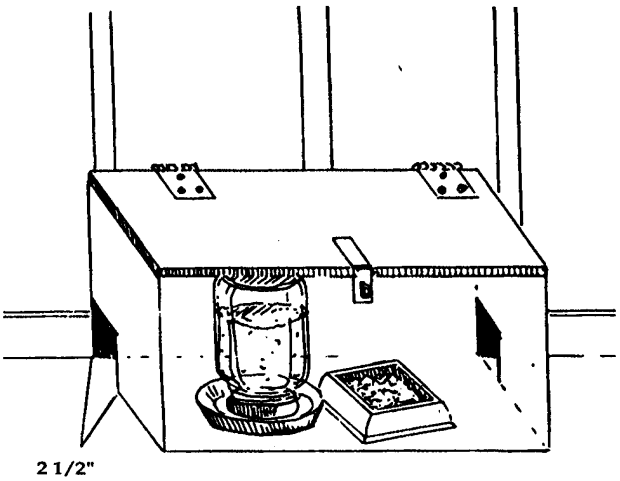


Figure 7-11. A homemade rodent bait station can contain liquid as well as solid baits. This bait station allows rats to feed in a sheltered location while preventing pets, children and other non-target species from reaching the bait.

Proper placement of bait stations is just as important as using the appropriate bait. Rats will not visit bait stations if they are in an inconvenient location where rats are not active. Bait stations are more effective for Norway rats than roof rats, because of the difficulty of placing bait stations along rafters or ledges where roof rats are active. Paraffin-type bait blocks provide an alternative when controlling roof rats. When possible, place bait stations or bait blocks between the rodents’ source of shelter and their food supply. Place bait stations or blocks near burrows, against walls or along travel routes. Since rats are suspicious of new or unfamiliar objects, it may take several days for them to enter and feed in bait stations or eat bait blocks. When first putting out bait boxes, inspect daily and add fresh bait as needed. After a short time, rodent numbers and feeding will decline, and the boxes can be checked less frequently, e.g., every two weeks or once a month. If bait becomes moldy,

musty, soiled or insect-infested, empty the bait station, clean it and refill with fresh bait, as rats will reject soiled or stale bait foods. Dispose of soiled or uneaten bait in accordance with the label.

Safety Precautions

Certain general safety precautions should be observed in addition to those appearing on labels of specific products.

- Consider all rodenticides dangerous enough to cause death, and place baits where only rodents can get them. No known rodenticides are without some hazard to nontarget animals. Be sure the baits are not accessible to children or pets and other animals.

- People handling baits should not smoke, eat, drink nor put their hands near their mouths. After preparing or handling baits, wash well using soap, a brush and plenty of water.

- Whenever possible, buy prepared or ready-to-use baits rather than trying to mix your own. Commercial formulators are governed by regulations that require that operations are safe for their employees. Wear gloves, protective eyewear and a dust mask/mist respirator when handling baits in nonpackaged forms. Clean all bait-mixing utensils thoroughly, and use them only for bait preparation.

- When toxicants are used, it may be advisable that each bait placement be recorded. Remove or destroy all uneaten baits at the end of the poisoning period according to label directions.

- Tracking powders are a Restricted Use Pesticide and should be used only in limited circumstances. As with any baiting material, certified applicators must wear gloves, protective eyewear and dust/mist respirators when applying tracking powders. Do not place poisonous tracking powders where the rodents might carry them on their feet or bodies to food or food-preparation surfaces. Do not place tracking powders in the vicinity where children, pets and nontarget species frequent.

- During and after a poisoning program, pick up all dead rats. Handle the carcass using rubber gloves or a pair of long tongs. To dispose of large numbers of dead rats, burn (unless prohibited by law) or bury deep enough not to be dug up by pets or other carnivores. If there are only a few dead rats, place them in a plastic bag, close it tightly and dispose with the garbage.

- Label all bait containers or stations, unused baits and rodenticide concentrates with an appropriate warning. Store unused bait away from children, preferably in a locked place. Keep all rodenticides in locked and labeled cabinets. Restrict access to authorized, responsible individuals.

What Isn't Recommended

There are a number of commercial products that are ineffective at controlling rat populations or are not recommended around homes because of their hazardous nature.

- Frightening devices producing ultrasonic sounds are commercially available, but their effectiveness is unsubstantiated by scientific research. Therefore, these are not recommended as a solution to rodent problems. Loud or unusual noises may temporarily frighten rats, but they soon become accustom to new sounds heard repeatedly.

- Repellents such as mothballs or household ammonia may temporarily move rats from one location to another, but do nothing to remove the rats. A product called Ro-pel is registered for use in repelling rodents from gnawing on trees, poles, fences, garbage and other objects, but will do nothing to remove them.

- Fumigants typically are not an option in homes. Some fumigants are registered for use in rodent burrows at outdoor locations. Compounds including aluminum phosphide, chloropicrin and gas cartridges are registered for this purpose. Fumigants should only be used by pest control operators who are familiar with the necessary precautions for fumigation, because these fumigants are highly toxic to humans and other animals. Do not use fumigants in any situation that might expose the occupants of a building to

the fumes. To fumigate Norway rat burrows, close the burrow opening with soil or sod immediately after introduction of the fumigant. Norway rat burrows often have multiple entrances, and all openings must be sealed for fumigants to be effective. Fumigants are less effective in soils that are very porous or dry. Since roof rats rarely dig burrows, burrow fumigants are of limited use.

- Tracking powders can be effective at rat control but are not recommended around homes. When rats walk over a patch of toxic powder, they pick up some on their feet and fur, and later ingest it while grooming. Tracking powders are used in situations where food is plentiful and good bait acceptance is difficult to achieve. The concentration of active ingredient in tracking powders is considerably higher than food baits using the same toxicant; therefore, powders are more hazardous. Tracking powders are used much less often for roof rats because roof rats frequent overhead areas, where it is difficult to find a suitable place to apply tracking powder without contaminating food, materials or people below. Many, if not all, are Restricted Use Pesticides.

Concluding Remarks

An effective rodent control program can be achieved through a combination of sanitation practices and habitat modification, rodent-proofing and population reduction. In areas with moderate to severe infestation, a cooperative effort among adjoining properties will be necessary to achieve long-term, effective rodent control measures. Otherwise, rats from surrounding habitats can be expected to "fill the void" and return to the unoccupied rodent habitat in the home. Many commercial products are available for rodent-proofing homes, and trapping and baiting rats. Rodenticides (toxic baits) can pose a risk to the handler, children, pets and nontarget wildlife species. Safety considerations should be a priority when implementing these techniques. Because of product turnover, information presented in this chapter may become outdated. Always follow the pesticide label when applying baiting practices.

Skunks

Skunks are classified as furbearers and, as such, are protected by state regulations. A hunting license is required from the Arkansas Game and Fish Commission (www.agfc.com) for either live trapping or administering lethal methods of control. With a hunting license, skunks may be live-trapped or killed during furbearing season. If skunk problems need to be handled outside furbearing season, a depredation permit is required. Contact a county Arkansas Game and Fish wildlife officer or wildlife biologist for this permit. Note that a depredation permit does not include permission to shoot skunks when local law prohibits discharge of firearms.

Skunks have short, stocky legs and disproportionately large feet equipped with well-developed claws for digging. Skunks are carnivores and eat insects such as grasshoppers, beetles and crickets, as well as mice, moles, young rabbits, grubs, bees, wasps and their hives. Skunks also eat fruits, some grasses, leaves, buds, roots, nuts and grains. In residential areas, they contribute to controlling rodents as well as insect pests found around the home; however, their underground dens can weaken foundations and contribute to odor problems.

Skunk Control Techniques

Skunks occasionally become pests by living near or beneath residences. Although a chief objection to their presence is the penetrating odor they produce, skunks can carry rabies. Skunks that are overly aggressive or show abnormal behavior should be treated cautiously. Contact local animal control or sheriff's office for assistance with disposing of a rabid skunk. Avoid shooting or striking the head to protect against damaging the brain for testing rabies. If removing a potentially rabid skunk, gloves and/or shovels should be used. Place skunk in a sealed plastic bag and bury the carcass where pets will not dig it up.

Removal and relocation in combination with exclusion methods oftentimes is the best option for addressing skunk problems. Shooting is also an option, where legal and with proper hunting license or depredation permit. There are no toxicants or repellents registered for skunks.

Typically, skunk problems involve removing and excluding skunks from a den site. Avoid skunk removal from May through early August when

den-bound, immobile young may be present. A combination of live trapping, relocation and exclusion are recommended as follows.

- **Live trapping**. Bait live traps with a few tablespoons of pet food having a fish base. When using a wire cage trap, place a tarp or plywood shell around the cage. Check the trap frequently particularly in the summer, as skunks could die from excessive heat and lead to accusations of inhumane treatment. After a skunk is trapped, cover the opening so the skunk cannot see. With a minimum of jarring or shaking, the trapped skunk can be transported and released with little concern for a musk discharge. Leg-hold traps can be used to catch skunks, but because of odor problems, this method should not be used near housing.

- **Relocation**. When relocating skunks, transport them at least 10 miles and release in habitat far from human dwellings.

- **Exclusion**. Typically, more than one skunk occupies a denning site. Seal off all foundation openings except one. Cover openings with wire mesh, sheet metal or concrete. Skunks may dig to gain entry, so obstructions such as fencing should be buried 1 1/2 to 2 feet. In front of the remaining opening, spread a layer of flour on the ground. Typically, skunks are active at night. Check at night for tracks indicating the skunks have left the den, then seal the opening. To ensure no skunks are sealed inside, use one or both of the following approaches.
  - For several successive nights, unseal one opening at dark and place flour on the ground. After a couple hours, check for tracks exiting the den and reseal the opening. If no tracks are detected after several nights, seal the opening permanently.
  - Place a trap inside the sealed up area. Bait with pet food and water. Remove and relocate any trapped skunks. Repeat until no skunks are trapped on successive days.

Odor Abatement

When a skunk raises its tail, it is a warning. When a skunk's hind legs begin hopping, leave the vicinity as quickly as possible. Ordinarily, there is no discharge. But if a skunk believes it is in danger, one discharge will not empty the reservoir. Many people find the odor repugnant or even nauseating. Because of its persistence, the scent is difficult to remove. Diluted solutions of vinegar or tomato juice can have limited effectiveness when applied to pets, people or clothing. Clothing can be soaked in weak solutions of household chlorine bleach or ammonia, but oftentimes the clothing is also ruined using this treatment. For spraying under foundations or structures, a number of skunk deodorizers are on the market. These offer some relief by masking, rather than removing, the odor. Merchants can be found on the internet, such as at http://crittercontrol.com/catalog/enter.html.

Snakes

There are 46 snake species in Arkansas, of which only 6 are venomous (poisonous). Most species are harmless to people. Snakes cannot be killed indiscriminately, as they are protected under the wildlife code of the Arkansas Game and Fish Commission. Snakes feed on rats, mice and insects, so they should not be killed unless they pose a direct threat to humans or pets. Only venomous snakes pose this threat, and it must be apparent and defensible. Wildlife officers have issued tickets and imposed fines for killing rattlesnakes. Venomous snakes rarely enter homes but can be found in yards.

Identifying Venomous Snakes

The most-often reported features for distinguishing venomous and non-venomous snakes are pupils, pits, and tail scales (Figure 7-12). Sometimes, the head shape is mentioned as well. Non-venomous snakes have a round pupil, no pit near the nostril and divided scales on the underside of the tail. Venomous snakes have an elliptical eye, a pit or opening close to the nostril and undivided scales on the underside of the tail. Of these features, only the presence or absence of a pit is consistent for identifying pit vipers. The shape of the pupil may vary depending on light conditions, tail scales may be difficult to detect and non-venomous species have head shapes that imitate their venomous counterparts. Only one venomous snake in Arkansas is not a pit viper, the coral snake. It can be distinguished by its coloration – a black snout with wide black and red bands on the body separated by narrow yellow bands. The similar-looking milk snake has a red snout with narrow black-yellow-black bands separated with wide red bands.

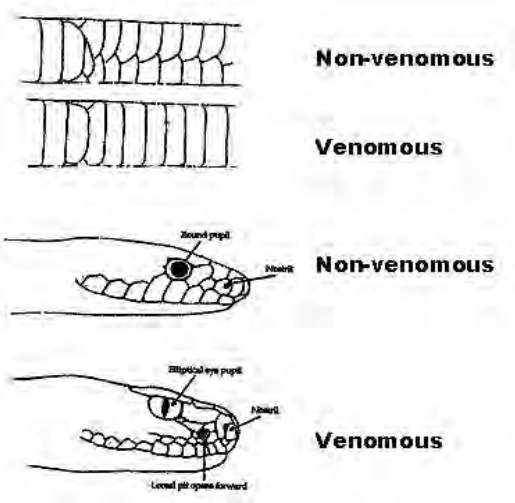


Figure 7-12. Characteristics of venomous and non-venomous snakes

Snake Control Techniques

Outside of rattlesnakes or copperheads, most other native snakes are quite harmless but cause concern when they enter buildings to escape the hot part of the day, seek food or hibernate during the winter. No toxicants are registered for snakes. Control measures are limited but can be effective.

- **Remove habitat.** Remove brush and lumber piles, and mow grass frequently. Not only will this remove hiding places for snakes, it also removes habitat for rodents. Often, snake problems follow rodent problems. Eliminate the rodents, the snake's food, and the snakes will move elsewhere.

- **Exclusion**. Seal all openings 1/4 inch (0.6 cm) and larger. Check the corners of doors and windows, and seal spaces around water pipes and electrical conduits. Seal holes in foundations with concrete. Patch holes in wooden buildings with fine mesh (1/8 inch, 0.3 cm) hardware cloth or sheet metal.

- **Snake-proof fence**. A properly constructed fence will keep out venomous snakes, though some non-venomous snakes are good climbers. Constructing a snake-proof fence is expensive but may be worthwhile in particular situations. The fence should be made of heavy galvanized hardware cloth 36 inches (91 cm) wide with 1/4 inch (0.6 cm) mesh. The lower edge should be buried 6 inches (15 cm) in the ground. The top of the fence should be slanted outward from bottom to top at a 30-degree angle. Place supporting stakes inside the fence. Gates should close tightly and swing inward, because of the outward slope of the fence. Any opening under the fence should be firmly filled. Concrete is preferable. Keep vegetation mown short around the fence, as a snake could use plants to climb over the fence.

- **Repellents.** Although repellents have been tried, evidence suggests they have little effectiveness. Currently, Dr. T's Snake-A-Way© is registered for rattlesnakes and checkered garter snakes. Active ingredients are sulfur and naphthalene (i.e., moth balls). A 6- to 8-inch band of product is applied to keep snakes from an area. If the band is broken, snakes can pass through.

- **Trapping.** A funnel or pit trap with drift fences can be used to capture and relocate snakes found in a yard. The fence is set up in a "V" shape with a funnel or pit trap placed at the intersection of the two fences. Drift fences can be constructed from 1/4 or 1/2 inch (0.6 or 1.3 cm) mesh hardware cloth that is 2 feet (0.6 m) wide and 25 feet (7.5 m) long.

- **Glue board.** A purchased or homemade glue board can trap snakes inside or under a building. Snakes become stuck when they travel across the board, then relocated and released by pouring vegetable oil on the glue. Put the captured snake in a cloth bag for transport. To construct a glue board for snakes, securely tack several rodent glue traps to plywood, or purchase the special glue in bulk and affix to plywood. The plywood board should be approximately 24 x 16 inches (61 x 41 cm) with a glue patch of at least 7 x 12 inches (15 to 30 cm). Drill a hole through the board so the snake and board can be moved with a long stick or hooked pole. Place the board along a wall where snakes are likely to travel. Do NOT place the board near any object, such as pipes or beams, a snake can use for leverage to free itself. Do NOT place the glue board in locations where it may catch pets, children or other wildlife. The glue is messy and can be difficult to remove.

- **Burlap bags.** Place piles of damp burlap bags or towels in areas where snakes have been seen. Cover each pile with a dry bag to slow evaporation. Snakes are attracted to cool, dark, damp areas such as these piles. After a day or so, take a large scoop or shovel and remove them during the day, when snakes are more likely to be inside or underneath the pile.

Responding to Snakebites

In the event of a snakebite, it is imperative to determine whether the snake is venomous. If possible, the snake should be positively identified or, if killed, carefully secured in a sealed container and transported with the victim for treatment at a hospital. Proper identification is necessary to insure the appropriate anti-venom is administered. Unlike the past, no extraordinary actions are recommended for snakebites other than keeping calm, avoiding quick movements, keeping the body part motionless and below heart level and quickly getting medical attention.

Tree Squirrels

There are three species of tree squirrels in Arkansas: gray squirrels, fox squirrels and flying squirrels. Squirrels are members of the rodent family, like mice and rats. Gray and fox squirrels are protected as game animals by state law with open and closed hunting seasons. Flying squirrels are protected as non-game animals and may not be hunted at any time. Flying squirrels typically do not create structural damage problems to buildings. Gray and fox squirrels often get into attics, walls and chimneys and may also eat flowers, shrubs and birdseed. They can store food and scratch inside attics and wall voids. They may travel on power-lines and short out transformers. Squirrels like to gnaw on wires.

Squirrel Control Techniques

Control methods for reducing squirrel damage can be more effective if used in combination. These methods are squirrel-proofing the structure, repellents, trapping and in some cases, shooting.

Squirrel Proofing

To eliminate squirrel problems in a building, find out where squirrels are entering. Gray and fox squirrels are active during the day, so you may be able to observe their activity. Common entry points for fox and gray squirrels are damaged attic louvers, ventilators, soffits, joints of siding, knotholes, openings where utility wires or pipes enter, chimneys and flashing. Squirrels may gnaw directly through siding and shingles, too.

Be cautious about squirrel-proofing from mid-February until April and from June through September when young are born, particularly if there is evidence that squirrels are nesting in the structure. Squirrels typically have two litters a year, and their young are weaned at 6 weeks. The young may die inside the building, creating an odor problem as well as questionable ethics.

To repair openings, seal with heavy gauge, 1/2-inch hardware cloth or sheet metal. For details, follow instructions for rat-proofing that are in this chapter. Once all the openings are sealed, place a live trap in the attic where squirrels were active. This is a preventive measure in case squirrels were inadvertently trapped inside the structure. Such a squirrel will become desperate and can create extensive damage trying to escape. Continue to reset the trap until no squirrels are trapped for several days up to a week. Use instructions described below for setting live traps.

Squirrels can be stopped from traveling on wires by installing 2-foot sections of 2 to 3 inch diameter plastic pipe. Split the pipe lengthwise, spread the opening apart and place it over the wire. The pipe will rotate on the wire and the squirrel will tumble off. Be careful near high voltage wires.

Repellents

Naphthalene (moth balls) has been used to keep squirrels out of attics, particularly in summer homes and camps that are unoccupied in winter. There are bitter-tasting repellents on the market to keep squirrels from chewing on wood and plant materials and sticky repellents for repelling squirrels.

Trapping

Squirrels causing property damage may be live-trapped and released or killed under a depredation permit issued by the local wildlife enforcement officer. Live trapping can be used to remove one or a few squirrels from a building. Box or wire traps should be left open and unset for a few days, surrounded by bait, so that the squirrels get use to the trap. Good baits include peanuts, peanut butter, nut meats, whole corn, sunflower seeds or rolled oats. Good trap locations are the roof, the base of nearby trees or the attic itself.

Squirrels are nasty biters, so handle them carefully. Experts differ as to whether squirrels should be released or killed. If released, transport the squirrel at least five miles away so they do not return.

If a depredation permit is issued, rat snap traps can be used to kill squirrels in attics. The bait should be tied to the trigger and the trap nailed or wired to a beam.

Shooting

Squirrels causing property damage may be shot under a depredation permit issued by the local wildlife enforcement officer, if discharging a firearm is legal at the site. Gray and fox squirrels may be shot without a permit during declared open squirrel season, if local ordinances allow discharging firearms.

Acknowledgements (Vertebrate Pests)

Major portions of text and illustrations for this chapter on vertebrate pests were taken from publications written by:

General Pest Pesticide Application Manual: Industrial, Institutional, Structural, and Health Related (1999), Oklahoma Cooperative Extension Service.

Robert M. Timm, Rex O. Baker, and Gerald R. Bodman in *Prevention and Control of Wildlife Damage* (1994 edition), Nebraska Cooperative Extension Service.

Rebecca McPeake, Blake Sasse, and David A. Saugey in *Bats in and Around Your Home* (2002), University of Arkansas Cooperative Extension Service. (FSA9088)

Using Pesticides: Commercial Applicator Manual, Pest Control Category (2002), Texas Cooperative Extension Service.

Arkansas Nuisance Wildlife Control Guidelines (1999). Arkansas Game and Fish Commission, Little Rock.

Additional information was used from:

"The House Mouse: Its Biology and Control," (1981 edition) by Rex E. Marsh and Walter E. Howard, Div. of Agric. Sciences, Univ. of California.

"The Rat: Its Biology and Control," (1980 edition) by Rex E. Marsh and Walter E. Howard, Div. of Agric. Sciences, Univ. of California.

Equipment and Application Techniques

Learning Objectives:

After completion of the study of Equipment and Application Techniques, the trainee should be able to:

- Discuss the characteristics, advantages and limitations of various kinds of control equipment.
- Discuss proper maintenance of equipment.

Those involved in pest control should know the characteristics, advantages and limitations of various kinds of control equipment so they can choose the equipment best suited to each job and use it safely and effectively. Proper maintenance of equipment is important to safety and efficiency and also to profitability, in that it prevents costly repairs.

Along with a knowledge of equipment, pesticides and pests, the applicator must be thoroughly familiar with the application techniques suited to a given situation. Many current and all future pesticide product labels will indicate how a pesticide is to be applied. Application techniques vary with the equipment used, type of pesticide applied, target pest involved and size and scope of the application job involved. Proper application techniques ensure effective control, proper use and prevent drift and pesticide loss into the environment.

Equipment Sprayers

Compressed Air Sprayer

The basic piece of spray equipment used in general pest control is a small, hand-operated and hand-carried compressed air sprayer with a capacity in the range of 1/2 to 1 1/2 gallons. Air pressure is supplied by a hand-operated pump or by an electrically or gasoline operated air compressor. The air pressure is contained in the tank above the surface of the liquid to be dispensed. This air, usually compressed to 20 to 50 pounds of pressure, forces the pesticide out through a discharge tube to the nozzle when the discharge valve is opened. The liquid is not mixed with air, but is pushed out as a wet spray without atomization. There are several sprayers of this type made by several different companies. The pest control operator should choose the type best suited to his needs.

To control a variety of insects – cockroach, ant, flea, stored product pests and numerous other types of pests – the general pest control operator uses these sprayers. It is used for applying crack and crevice, spot and general sprays. It is the workhorse of a pest control operation.

A compressed air sprayer consists of:

- a tank for the spray mixture,
- a hand-operated pump for compressing air in the tank,
- a siphon tube to carry the spray mixture to the hose,
- a hose which connects the sprayer tank and siphon tube to the valve,
- a valve to control the spray flow, and
- a nozzle to distribute the spray in the desired application pattern.

Use a wand or short piece of curved tubing to extend the distance between the valve and nozzle. Compressed air forces the spray material out through the nozzle when the valve is open.

Hand-operated compressed air sprayers are designed to operate with 20 to 50 pounds of air pressure. Usually, pressure of less than 20 pounds is desirable when operating indoors, such as when making crack and crevice applications. The reduced pressure results in reduced splashing. Higher pressures of 20 to 50 pounds are necessary when operating outdoors, projecting a spray stream over long distances, spraying large volumes and to develop proper nozzle patterns when using fan or cone nozzles.

The tank is made of stainless steel, brass, galvanized steel or plastic. Stainless steel tanks are generally resistant to the corrosive effects of many pesticides. Some tanks may have an air release valve and/or a pressure gauge.

The air pump is usually mounted in the cover of the head opening. It consists of a handle, cap, sealing ring, plunger rod, piston to force air into the tank through a check valve in the bottom of the pump and a brass, stainless steel or plastic cylinder. The piston has a leather or synthetic rubber cup, which may require maintenance. The check valve at

the bottom of the pump cylinder prevents air and spray material from being forced back into the cylinder. The check valve may also require periodic replacement.

The nozzle is the most important part of the sprayer because it determines whether the insecticide will be sprayed as a solid stream, flat spray, hollow cone or solid cone. It also determines the rate of spray output at a given pressure, the thoroughness of application and the safety with which a spray is applied.

Nozzles are available in many types, each designed for a specific delivery pattern and discharge rate. Base the selection of nozzles on the proper particle size and application rate. Solid stream nozzles are used in crack and crevice treatment. Use fan nozzles in making flat surface applications. Solid and hollow cone nozzles distribute sprays in a circular pattern and are used more often in applications to trees and shrubs. Adjustable nozzles containing a variety of tips are available and useful when varying spray patterns.

If a sprayer is used daily, clean it after each use. When cleaning the tank, use hot water and a good detergent, preferably one containing ammonia. Remove any residue accumulations on the inside of the tank by scrubbing the inside and bottom of the tank with a stiff bristle brush until the surface is perfectly clean. Clean and polish the outside of the tank to preserve the surface and to prevent contamination or damage to other objects. Pressurize the tanks after cleaning to check for small pinhole leaks.

Store upside down when the sprayer is not in use. Remove the pump unit and turn the tank upside down, lay the pump assembly on a clean surface, hang the shutoff valve on a hook and let the hose extend its full length. Open the shutoff valve so that any liquid trapped in the extension can drain out of the hose. Sprayers need to be protected during freezing weather to prevent damage (e.g., valves may freeze and crack).

Inspect the pump unit and maintain the three gaskets. At two- or three-week intervals, lubricate the cup leather of the pump with a few drops of neat's-foot oil. Oiling the cup leather in this manner helps retain its shape and keeps it moist for maximum efficiency when pumping. The sealing ring, in time, becomes worn and needs replacing. When worn out, this gasket can cause severe pressure leaks.

Periodically inspect the lip of the pump cylinder for cracks as this causes pressure loss around the pump cap. Clean and polish the inside of the pump cylinder. Remove the check valve and polish the valve seat with steel wool.

Sprayer malfunction often occurs within the pump assembly. Proper diagnosis will indicate the problem that may require repair or replacement. Frequent replacement of the gaskets is much less costly, in most instances, than solving the problems of accidental pesticide discharge.

Problem

- Failure to develop pressure or no back pressure when plunger is pushed down.
- Liquid or air flows into pump, causing liquid to shoot up out of the cap around the handle, or the handle "creeps" up when not locked down.
- Sprayer loses pressure slowly, even when no spraying is being done.

Cause or Answer

- Worn plunger cup or plunger cup needs oiling.
- Worn check valve.
- Worn sealing ring.

Thoroughly inspect, rinse and clean the sprayer hose once a week. This is most convenient when the tank is rinsed with detergent. After the tank has been washed thoroughly, pressurize the sprayer and spray the detergent through the hose, shutoff valve and nozzle. Never let the sprayer hose stand unused for more than one day with pressure in the sprayer. Even the best sprayer hoses show some deterioration if left standing under pressure when filled with solvents and insecticides. Never leave an unattended sprayer of any kind under pressure. The next person walking by may try the shutoff valve and contaminate himself or the area. Loosen the cap slowly. After the pressure is released, extend the hose upward full length and depress the valve. This allows spray material accumulated in the hose, valve and wand to drain back into the tank.

Occasionally oil the valve plunger and replace the packing around it. When the valve fails to feed or stops up when operating, it may be clogged. The valve may fail to shut off completely, permitting a

continued drip from the nozzle. There may be some dirt lodged in the valve seat, or there may be a scratch on the valve surface. When these problems occur, take the valve apart. The manufacturer can provide the necessary diagrams and instructions to aid in this procedure.

The strainer assembly of any sprayer is a very important part. A properly functioning strainer filters out particles that would clog nozzle tips or interfere with shutoff closure. Remove the assembly once a week and wash thoroughly to remove all sediment and residue from the strainer screen. Otherwise residue builds up on the screen and stops the flow of insecticide. Normally, these sediments can be removed by running hot water over the strainer. If necessary, soak the strainer a few minutes in a suitable solvent and clean with a soft bristle brush.

Nozzle tips occasionally become clogged with extraneous materials that distort the spray pattern or completely prevent liquid passage. There are several remedies for clogged tips. Use compressed air to blow foreign matter out of the tip, and for best results, always force the air through the front of the orifice. Soaking the tip in a suitable solvent and cleaning with a toothbrush usually cleans out the accumulated sediment. Never use anything more rigid than a toothbrush bristle to clean the spray tip, and never insert any metal object such as a pin, wire, etc., into the end of the tip. The orifice is precision machined and can be marred easily, causing a distortion in the spray pattern.

Small Hand Sprayers

There are uses for even small hand sprayers in public health programs. The “flit gun” type sprayer and the pistol sprayer can be used for treating very small areas when extreme portability is important or when only small quantities of pesticide are needed as when treating small mosquito-breeding areas or wasp nests.

Dusters

Equipment for applying dusts varies with the use and the type of practice. Some of the more common types of dusters are:

Hand Shakers

Hand shakers are available in a wide range of sizes or can be homemade. Shakers may be used for applying tracking powders and patches for mice and rats in runs along the base of walls or foundations or on beams. They may be used for insects where careful placement and neatness are not essential. Do not apply too much in one place. If the shaker is fitted with a 16- to 20-mesh screen, over-application is less likely to occur.

Hand Bellows Duster

A hand bellows duster is a rubber cylinder with a metal or plastic top and bottom. The bottom has an extension tube for delivery of the dust. The top contains an opening for filling and a tight stopper.

Inside the rubber cylinder is a large coil spring that resumes its shape after compression. The dust is delivered by squeezing the top and bottom of the bellows together. This duster is used where small quantities are needed, and careful placement and neatness are important. They are used to apply a thin layer of dust or to force dust into small cracks or voids where insects may be hiding. They are sometimes used for cockroach control or treating nests in wall voids.

Bulb Duster

A bulb duster is a rubber bulb with a screw cap cover fitted with a dust nozzle. Dust is distributed by squeezing the bulb. These dusters are used in the same situations as hand bellows dusters.

Hand Plunger Dusters

Hand plunger dusters consist of a plunger-type pump and a metal or glass reservoir into which the airblast goes when the plunger is pushed. The dust is dispersed as a relatively fine cloud or a heavy blast, depending on how the duster is held. They are not suitable for most inside work but are sometimes used for treating large areas, such as crawlspaces or attics, when larger rotary or power dusters are not available. They might be used to apply insecticide dusts for silverfish and spider control in attics or crawlspaces.

Foot Pump

A foot pump is similar to the hand plunger duster but is held down on the ground by placing the foot in a stirrup and pumping with the hands to force the insecticide out through a short, flexible delivery tube. It is useful for applying dusts to rat burrows.

Rotary or Hand Crank Dusters

These dusters have a 5- to 10-pound capacity hopper. Some are designed to be carried on the operator's back. When the crank is turned, a fan blows air through a long delivery tube. Dust is dropped into a mixing chamber or directly into the fan chamber from a hopper, which may or may not contain an agitator to fluff the dust and feed it into the fan for dispersion out the tube. Most have adjustments to regulate the delivery rate of the dust. Usually a fan-shaped tip is supplied with the duster to produce a broad band of dust. With the fan tip removed, it can be used to treat rodent burrows. These dusters are primarily for outdoor use but are also used to treat larger indoor areas, such as crawlspaces and attics and for treating sewers.

Power Dusters

Power dusters vary in size and output. They are similar in principle to the crank dusters but have a larger capacity and power-driven fans and agitators. Small electrically driven dusters produce a very fine layer of dust and are used effectively to treat small cracks or wherever deep penetration is required. Another type of power duster is the compressed air duster. It is similar to a dry-type fire extinguisher and must be pressurized with air before operation. A mixture of dust and air is discharged when the valve handle is depressed. These dusters would also be used to treat attics and crawlspaces to control several kinds of insects that may be a problem in these areas.

Most dust application equipment is maintained easily, but periodic maintenance is essential to keep this equipment in effective working condition. Empty dusters frequently. Clean thoroughly to remove all caked or hardened dust. Insert a piece of stiff wire in the tubes to scrape caked dust from the sides and tip of the tube. Clean screens and all other small openings frequently to ensure they are not clogged. When storing the duster, first remove all dust and then clean thoroughly. Be especially careful to purge the foot pump duster after use of calcium cyanide. Make sure the storage area is dry so that metal parts do not rust.

Space Treating Equipment

Space treatments for quick knockdown and control of flying insects have been used extensively. Any insecticide used to fill a space must first be broken down into fine particles or droplets to allow their suspension in air or to allow the particles to be moved by wind currents. Fine-droplet dispensers-foggers, misters, aerosolizers and ultra-low dose (ULD) applicators were developed for this purpose.

Equipment used in dispensing fine particles comes in a variety of types and sizes, each designed to produce particles within a specific range of sizes. At present, there are no particular field methods for determining droplet size quickly. Equipment can be adjusted within certain limits to produce a wide range of droplet sizes.

It is a common mistake to relate the type of application specifically to the piece of equipment being used. To be effective, safe and efficient, know fogs, mists, aerosols and ULD in terms of droplets size and their characteristics and usages in given control situations; then use the proper equipment for the purpose.

Distribution and effectiveness of insecticides in space treatments are dependent on the production of very small drops in much larger numbers than with conventional application methods. These very fine drops, however, are more subject to drift and tend to deflect around target insects instead of hitting and impinging on them.

The micron (a unit of measurement) is used to measure droplet or particle size. One micron equals 1/25,000 of an inch.

Effectiveness of spray droplets depends on their size, their ability to penetrate or to reach the target area and their ability to impinge on or hit the insect. Research indicates that droplets in the 5- to 15-micron range (most conventional spray droplets are in the range of 100 to 400 microns) are more efficient for controlling cockroaches and other structural pests.

Spray droplet size is affected by the pressure or flow rate, the size of the outlet orifice and the viscosity and physical characteristics of the spray mixture. The higher the air pressure or flow rate or the smaller the orifice outlet, the smaller the droplets produced. Viscosity affects flow rates and evaporation rates; higher viscosities generally reduce both rate of flow and evaporation.

Penetration of droplets into an area not in direct line with the spray outlet is dependent primarily on droplet size, speed or velocity of the droplets, air currents and gravity. Impingement is affected by the same factors affecting penetration plus the size and shape of the target insect.

Factors influencing the effectiveness of conventional sprays also affect fine particle dispensing, including the insecticide used, concentration and rate of application, thoroughness of application, amount of harborage area (hiding places) and the nature of the treated surfaces.

Aerosols

Insecticides in extremely fine mists are aerosols. Aerosols used indoors may be gas propelled or thermally released.

Gas-propelled aerosols are insecticides in special containers in which a liquefied gas is used to force the contents under pressure out through the nozzle in droplets of 0.1 to 50 microns. They are presently available in a variety of sizes from the disposable “soft drink” can size used by the public and industry to the heavier specially developed, reusable containers for use by industry for space, crack and crevice treatments. They are handy and convenient to use and require no special motors, electrical outlets, water or oil, but are more expensive per unit of insecticide. They are sometimes used for “flushing” or inspection to determine the nature of the problem, such as in cockroach control. Some are available with long flexible nozzles for crack and crevice treatments. Other aerosols are used in space treatments for the quick knockdown and control of crawling and flying insects and to increase insect activity to ensure contact with deposits of residual insecticides.

Aerosols may be purchased as timed-release dispensers with a clock-like mechanism that releases the spray on a preset schedule. Total release aerosols are being used increasingly. These dispensers contain residual or non-residual insecticides or both. They are designed so the release valve can be locked in an open position for total release of the contents.

Pressurized spray applicators are used commercially and by the general public. These spray applicators differ from aerosols in that they usually contain a much larger percentage of petroleum and diluent, and the nozzle produces a coarse spray that deposits a thin film of insecticide directly on surfaces.

Pressurized aerosols require some special care. Store them in temperatures between 70 and 120 degrees F. Higher temperatures increase the pressure within the container and can cause it to explode. Lower temperatures cause the pressure to drop, resulting in improper operation and larger droplets. Store and transport aerosols so they will not discharge accidentally.

Fogs

Fogs can be produced thermally or mechanically. A mechanical fog generator is most often a mist machine adjusted to produce fog-sized droplets. Most fogs, however, are produced thermally.

Fogs and aerosols technically are dispersions of droplets ranging from 0.1 to 50 microns with the preferred range of droplets thought to be 5 to 10 microns for greatest efficiency. Many formulations are produced for fogs or aerosol applications. Some specify the range of particles or droplets to use (i.e., none over 50 microns and 80 percent less than 30 microns). Fogs may be used to treat warehouses for stored product pests, cockroaches or other insects.

There are many makes, models and sizes of thermal fog machines available. These machines break the pesticide into fine droplets with hot exhaust gases. The hot exhaust gases vaporize the oil solution of an insecticide. As the vapor is discharged into the cooler outside air, it condenses into very fine droplets producing a fog. Some people believe heat causes some insecticide decomposition. Using less volatile oils may minimize this. Thermal fog generators sometimes produce a flame when started and should be started outdoors or in a safe area. If a fogger ceases to function, take it outside to restart it.

Thermal fogs may be used alone, indoors or along with residual applications for controlling crawling insects. Indoors, fog rarely penetrates into cracks and crevices unless air currents are running into such areas to carry the fog with it. Fogs usually do not move against cold exterior walls.

Thermal fogging can cause explosions. Usually, this is the result of having too high a concentration of fog in the structure and operating near a spark or flame, which ignites the explosive mixture. Turn off

all pilot lights by shutting off the main gas valve rather than individual valves. Wait until the gas in the line has been used and the pilot lights go out.

The concentration of fog can be too high from overdosing or from pockets of accumulated fog material. Good practice and most labels call for using 21 gallons of fogging compound per 50,000 cubic feet, which is well below the explosive limit, but an open flame can ignite the oil and cause a fire. Know the cubic footage of the area being treated and the amount of fogging mixture to put into the space. Then you must know how fast your fogger puts out the mixture. Record the information so you do not have to recalculate if retreatment is required.

Mists

Mist particles or droplets range from 10 to 80 microns in diameter and can be dispersed using oil or water as a base. Since mists are generally larger particles than other types of space treatment, they settle out fairly rapidly. Use mists in conjunction with a residual treatment for long-lasting control of crawling insects, but apply them following the residual application. Mists, like fogs, are used more frequently in warehouses.

Mist-producing applicators break up the insecticide mechanically into fine particles using low pressures and a high volume of air. The smaller units most commonly used inside are electrically driven at high speeds. Some force air and liquid through a hollow shaft and between pairs of disks by centrifugal force. A blower on the same shaft blows across the outer edges of the disks, shearing droplets off and into the outer edges of the disks, shearing droplets off and into the airstream at high speed. Particle size depends generally on rotation speed, delivery rate and viscosity of the insecticide solution or emulsion. Others produce an airblast that sucks the spray mixture from the tank, shears it into a fine insecticidal mist and projects it for several feet.

Mist applicators are available in a wide range of sizes and can be used to apply oil-based sprays or water emulsions. They have low manpower requirements and can apply small amounts of toxicant to a large area in a short time. Oil-based mists can be ignited by an open flame but are generally considered less hazardous than thermal fogs. Water-based mists have no fire or explosion hazards. When used outside, the insecticides may spot cars and windows. The oil may burn shrubbery if the machine is not properly operated.

Ultra Low Dosage (ULD)

ULD uses high concentrations of insecticide (as fine droplets) at reduced application rates. A very high percentage of the droplets are produced in the range of 1 to 30 microns with none exceeding 50 microns in size. The droplet size appears fairly uniform. Distribution and effectiveness depend on the production of very fine drops in much larger numbers than with conventional application methods. These very fine drops, however, are more subject to drift and tend to deflect around target insects instead of hitting and sticking to them.

There are many makes, models and sizes of ULD applicators available. Some have fixed nozzles, while others have remote nozzle hose assemblies. They may be powered by electric motors, gasoline engines or by compressed gases (pressurized aerosols). In the electric- and gas-powered units, the insecticide is drawn into the nozzle and forced out at high speed, producing small droplets. A supercharger usually produces pressure in these units. Follow the manufacturer's directions to obtain the desired range of droplet size. Both oil- and water-based formulations are available for use in this equipment.

ULD treatments provide good flushing action for cockroaches, but should be used after first making a residual treatment. Since ULD involves the use of higher than normal concentrations and lower than normal application rates, this information must appear as a part of the labeling to avoid misuse of the product. At this time, the number of insecticides registered for ULD use is limited.

The disadvantages of ULD in comparison to conventional space sprays are poor residual life, chemical slick if oversprayed, poor results in ventilated areas, the necessity of wearing protective equipment, a certain degree of fire and explosion hazard compared to conventional space sprays and the necessity of applying at a time when the area is unoccupied. If a gasoline-powered spray unit is used, the additional disadvantages of carbon monoxide and noise may be a factor. Because droplet size is critical, maintain the equipment and operate at specific pressures and flow rates.

The advantages of ULD include shorter treatment time and lower fire and explosion hazard

than with foggers. Other more debatable advantages include deeper penetration, more thorough flushing action and more effective use of the insecticide.

Information provided by the manufacturer for care and maintenance of equipment should be consulted. The following general considerations and safety recommendations for using fine droplet-dispensing machines may also be useful.

- Maintain the equipment well. The engine should run evenly at the proper speed. Keep the engine well tuned. The flow rate or pressure must be correct.
- Allow use only by an experienced operator trained in safe and effective use.
- Keep insecticides and solvents at room temperature. Low temperatures (less than 50 degrees F) increase viscosity and cause larger droplets to form, resulting in poorer control and a tendency to create oil slicks on horizontal, hard-finished surfaces.
- Direct the insecticide into harborage areas for maximum penetration and greatest contact with the pests.
- Reduce airflow and air currents in treatment area by closing doors and windows to allow droplets to stay in suspension longer.
- Shut off the ventilation system.
- Turn off smoke alarms.
- Do not use more than one gallon of oil solution to 50,000 cubic feet of space.
- If using gasoline engines: Start engines and generators outside if possible. Keep engine mufflers, exhaust pipes and the hot tip of the generator away from combustible materials and items that might be damaged.
- If using oil-based materials: Extinguish all flames and pilot lights. Use only those diluents approved by the machine manufacturer. Notify local fire authorities. Have a fire extinguisher handy.
- Use only materials and formulations registered for use in your application equipment.
- Keep the treated area closed and secured for as long as specified on the label.
- After the treatment and exposure period has been completed: Open doors and windows. Remove any seals. Ventilate thoroughly (30 minutes or longer) as specified on the label. Inspect and clean up. Remove warning signs. Turn on utilities that were shut off, making sure that all pilots are relit.
- Use after residual treatment for crawling insects.
- Follow label instructions.
- Follow safety precautions: Remove occupants, pets and birds. Cover or remove plants and aquariums. Remove food or place it in tight containers. Cover food preparation surfaces or clean after treatment. Wear an approved respirator and goggles. Applicators should work in pairs and in sight of one another in large buildings if the machine is operated indoors. Post warning signs at all entrances.

Fine droplet-dispensing equipment requires continuous maintenance because the equipment is costly and because it will not dispense correct particle sizes and dosages unless properly maintained.

Keep instructional materials, diagrams and other information supplied by the manufacturer readily available. Consult this literature for instructions when you disassemble equipment during maintenance or repair.

All moving parts of fine droplet-dispensing equipment should be routinely inspected, cleaned and lubricated if necessary. Give particular attention to those parts that regulate calibration or droplet sizes to ensure they are in good working order.

Foggers and heat generators require special attention. The high degree of heat in these machines causes a carbon formation from the insecticide formulation, which must be removed regularly to prevent interference with the normal flow of insecticide through the machine. Remove carbon immediately after each use before it hardens or builds up into a thick layer. Heated carbon particles could dislodge and start a fire. It is especially important not to damage any portion of the heat chambers or any small orifices that may be present.

Using Pesticides Safely

Learning Objectives:

After completion of the study of Using Pesticides Safely, the trainee should be able to:

- Discuss the uses and hazards of the materials to be used in general pest applications.
- Understand the importance of label information.
- Discuss the minimum safety requirements of pesticide application.

The pesticide applicator should be thoroughly trained in the uses and hazards of the materials being used. The applicator is responsible for preventing adverse effects to the public, to pets and domestic animals, to property, to the environment, and to themselves and other applicators. In addition, the application must achieve effective results on the pest problem being treated.

Label Information

By definition, the label is the information printed on or attached to the pesticide container. Labeling includes the label and all other written, printed or graphic material accompanying the pesticide. It is a violation of federal law to use pesticides in a manner inconsistent with labeling.

The importance of reading the label cannot be over stressed. The information that appears on the label represents some of the most expensive literature available. The research and development that lead to the wording on a label frequently costs millions of dollars and takes many years to complete. The information on the label is the best literature available on the safe and proper use of the chemical. The most important few minutes in pest control is the time spent reading the label.

Please refer to the chapter on Labels and Labeling in the manual entitled Applying Pesticides Correctly for a discussion of the basic information that appears on every pesticide label. The following is a discussion of terms that are found on labels frequently used by the pest control industry.

Some information appears on the labels of insecticides used by pest control operators that is rather specific to the industry. This information is extremely important since the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) states it is illegal to use any pesticide in a manner inconsistent with its labeling. A specific example where this information is important to the pest control industry involves the use of pesticides in food-handling establishments. You may only use those insecticide formulations that bear directions on their labels for use in food-handling establishments. Typical labels have wording such as “Food Areas: limited to crack and crevice treatment only...application of this product in the food areas of food-handling establishments other than as a crack and crevice treatment is not permitted.” Some important definitions of terms that appear in labeling with respect to use in food-handling areas are discussed below.

Definitions of Terms Found on the Label

Tank mixing. Many labels will permit tank mixing with other pesticides, unless the other pesticide label prohibits the mixing. Some pesticides will explicitly prohibit mixing certain pesticides. The applicator must be aware of such label directions.

Treatment sites. Many labels will list sites/areas that the pesticide can be applied. The applicator must be aware of these areas and the areas not listed. For example, if apartments or apartment buildings are not listed on the label, the product cannot be used in apartments.

Food-handling establishments. An area or place other than a private residence in which food is held, processed, prepared and/or served. (“Held” includes displayed for sale as well as stored.) Some places “other than a private residence” include: restaurants, lunchrooms, caterers, cafeterias, bars and taverns, private clubs, military messes, officers and NCO clubs, food contractors in plants and office buildings, mobile caterers, airlines, ships, drug stores, confectionery stores, dairy products stores, bakery product stores, drive-in movies, school lunch rooms, colleges and universities, hospitals, homes for aged, orphans, and handicapped, federal and state prisons and jails. Private

residences are excluded; however, you should be alert for any possible changes in the future that might place private residences under this definition.

Non-food areas. These include garbage rooms, lavatories, floor drains (to sewers), entries and vestibules, offices, locker rooms, machine rooms, boiler rooms, garages, mop closets and storage (after canning or bottling).

Food areas. These include areas for receiving, serving, storage, packaging (canning, bottling, wrapping, boxing), preparing (cleaning, slicing, cooking, grinding), edible waste storage and enclosed processing systems (oils, dairies, edible oils, syrups).

Residual insecticides. These include products applied to obtain insecticidal effects lasting several hours or longer and which are applied as general, spot or crack and crevice treatments. Residuals include insecticides that remain on the treated surface for days. These usually provide insecticidal effects lasting several hours or longer and are, therefore, considered residual by the EPA.

There are three types of residual applications recognized by the EPA: general, spot and crack and crevice. Each may be used in certain areas if specified on the label and are defined as follows:

General. This is application to broad expanses of surfaces such as walls, floors, and ceilings or as an outside treatment. This is permitted only in areas using only those insecticides so labeled.

Spot. This is application to limited areas on which insects are likely to occur and will not ordinarily be contacted by workers. These areas may occur on floors, walls, and bases or undersides of equipment. For this purpose, a "spot" will not exceed two square feet. In order for spot treatments to be justified, there must be a surface on which insects are likely to occur. A "spot" may be round or long and narrow. This indicates that a considerable area could be treated but in practice, the area must be limited to places where insects are present or are likely to occur.

Crack and Crevice. This is application of small amounts of insecticides into cracks and crevices in which insects hide or through which they may enter a building. Such openings commonly occur at expansion joints between different elements of construction and between equipment and floors. These openings may lead to voids such as hollow walls, equipment legs and bases, conduits, motor housing and junction or switch boxes. The crack and crevice treatment includes the use of sprays, dusts or baits. It does not permit treatment of surfaces. In some cases, a pin-stream spray may be an acceptable application method, but a better approach may be to make application with an insertion tube directly into cracks and crevices.

Directions for use. The directions for use on a pesticide label include the site of application (crop, animal or surface) and the type of pests (insects, rodents, etc.) on which the product may be used. Methods of application and recommended dosage rates are also given. The label will normally give the concentration at which the pesticide is to be used. Dosage rates for pesticides used in general pest control are given as a certain percent concentration spray, such as 1/2 percent or 1 percent spray. The labeled products used for pest control provide dilution information to aid you in accurately preparing the volume of spray you need at label recommended strength. It is illegal to increase the concentration of any pesticide over the maximum application rate shown on the labeling. Also it is a conflict of usage to change the method, time of application or other conditions of use shown on the label (to reduce the concentration below labeled rates is also considered a conflict of usage unless prior written approval is given by the Arkansas State Plant Board). It is extremely important to note those areas listed on the label where the pesticide can be used. Specifically, pesticide labels will indicate either indoor or outdoor use.

Safety Procedures

The hazards of a pesticide depend more on how it is used than how toxic the material is. Consider all pesticides as being toxic. Pesticides may enter the body through the mouth, skin or by breathing the vapors or dusts. Possibly the greatest hazard from pesticides is from skin absorption of pesticide concentrates due to the sheer volume the applicator handles. The inhalation of fumigants, dusts or vapors can be equally hazardous if proper protective measures are not observed.

Storage

Insecticides in warehouses should be placed in well marked, well ventilated areas, away from other types of pesticides and kept at temperatures that are not extreme (40 to 100 degrees F.) The storage area should be locked to prevent unauthorized persons from entering. Warning signs such as “Toxic Chemicals” should be placed on doors of chemical storage areas to protect firemen from toxic fumes in case of fire.

Container lids should be securely tightened and the containers placed on storage shelves after use. Incoming pesticides should be inventoried, checked for damage and leaks and promptly placed in the proper storage location. Broken and leaking containers should be removed immediately and the faulty containers disposed of properly (see Container Disposal). Spilled pesticide should be cleaned up and the area decontaminated (see the section on “Decontamination”). Many pesticides have a shelf life of six months or less after the seal has been broken and should be used before that time. If the labeling information does not mention shelf life, check with your supplier.

Chemicals carried in vehicles should be kept in locked boxes or locked inside the vehicle. Containers should be stored in weatherproof boxes with separators to prevent spills or breakage. Pesticides carried inside of vehicles should be stored so that fumes are prevented from reaching the driver’s compartment.

Pesticides should be kept in their original containers. Do not transfer pesticides into pop bottles, milk bottles, etc. When pesticides are transferred into service containers, the containers should be non-breakable and properly labeled.

It is recommended that the following clearly legible information be securely attached to the service container.

1. *Pesticide Concentrate.* If the service container holds a pesticide concentrate, the label should include:
    a. The name, address and telephone number of the pest control firm.
    b. Product name.
    c. EPA registration number.
    d. Name and percentage of active ingredient.
    e. Signal word from registered label.
2. *Use-Dilution Preparation.* If the service container holds a use-dilution preparation the label should include:
    a. The name, address and telephone. number of the pest control firm,
    b. Product name, preceded by the word “Diluted.”
    c. EPA registration number, preceded by the words “Derived from.”
    d. Name and percentage of active ingredients as diluted.
    e. Signal word from the registered label.

Pesticides should not be given away or sold to customers unless they are in properly labeled containers and are registered products.

Mixing, Measuring and Handling

Wear unlined neoprene gloves to handle pesticide concentrates, and use other protective clothing as needed. The pesticide label will frequently specify the type of protective clothing that should be worn. Pesti-cides should be handled in well-ventilated areas. The label may specify wearing a respirator to avoid breathing vapors or dust while measuring, mixing or applying the pesticide. Pouring of pesticides should be done below the genital region of the body since massive absorption of concentrates may occur if accidentally spilled on this region. Liquid-proof aprons can be worn to help prevent accidental exposures of this type. If concentrates are spilled on the skin or clothing, remove contaminated clothing at once, wash skin with cold water and shower with detergent and water. Wear safety glasses or goggles to prevent accidental contamination of the eyes. If pesticides are splashed into the eyes, rinse them with cold water for 10 minutes and see a physician.

Material placed in a hand sprayer should be mixed by turning the tank upside down at least 12 times to ensure a uniform mixing of concentrate with the carrier. Remember that wettable powders settle out of suspension rapidly when not constantly agitated. Power sprayers with mechanical agitators will keep powders well suspended, but roller pumps usually will not.

Equipment Use and Maintenance

Only properly maintained equipment will perform satisfactorily. Sprayers, dusters and misters should be kept clean and in perfect mechanical

condition. Leaky hoses, valves, tanks, lids and fittings should be repaired immediately. Failure to promptly repair leaks may result in contamination to clothing, staining, and puddling or present a hazard to the technician, the public and the environment.

Provide anti-siphoning devices on filling hoses or leave a 4- to 6-inch air gap between filling and tank so that pesticides in the tank will not siphon back into the water system. Never place a filler hose in a spray tank.

Application

Before applying any pesticide, read the label. Label information will frequently change; therefore, check the label on all the products for possible changes. Different manufacturers' labels for the same pesticide may vary; therefore, be certain the product you are using has the use registration for the particular pest that you are trying to control. The label will also give the approved application techniques to be used, i.e., general treatment, spot treatment or crack and crevice treatment.

Apply sprays, dusts, mists and vapors so the application has minimum contact with the product. Wear respirators approved by the Mining Safety and Health Administration (MSHA) or the National Institute of Occupational Safety and Health (NIOSH) when applying sprays, mists, aerosols or dusts under houses, in attics or in other confined spaces. Wash respirators thoroughly after each use and change the filters when they become depleted, or in accordance with label instructions. Clothing should be changed daily when using pesticides, and coveralls should be worn when treatment is made under houses. Wear unlined neoprene shoes or protectors over shoes when applying pesticides. Do not eat, drink or smoke while handling pesticides. Pesticides are readily taken into the body during these activities. After handling pesticides, wash your face and hands with soap and water before eating, drinking, smoking or using the bathroom.

You need to take every precaution to prevent pesticide drift from getting onto vegetable or flower gardens, clothes hanging on the line, cars, windows, dark painted surfaces that will spot, pet food and water containers, fish ponds, bird baths and outdoor furniture. Also remember that stains or discoloration can result from misapplication of pesticides to certain surfaces. Excessive dosages, over application, incompatible mixtures, solvent damage and spotting are some of the causes for staining. Generally, the higher the dosage, the greater the risk for staining. Excessively heavy application is the main cause for staining problems that you would not ordinarily have with the correct quantity of chemical applied. Soiled and greasy surfaces, new paint, some types of wallpaper, paneling and fabrics, certain plastic, and floor tile may be subject to staining. Emulsifiable pesticide formulations may stain new paint, paneling, wallpaper and plastics. Wettable powders may also spot many surfaces. Surfaces, such as upholstery, furniture, drapes, lower wall surfaces and clothing are some examples of items that should not even be treated under ordinary circumstances. If there is doubt about staining, "test treat" an area in an inconspicuous place, like a closet, to determine if you will experience a problem. If there isn't a stain within six or eight hours, it is likely that staining will not be a problem.

Over-application, use of a high odor chemical or a treated surface that reacts chemically with the pesticide may result in an undesirable odor. Good judgment in making pesticide applications will help avoid odor problems.

Incompatibility

Certain pesticides when mixed together in the same tank may form phytotoxic mixtures, fallout of suspension, neutralize each other, produce a more toxic mixture, stain or clog application equipment. Some materials will not mix together at all. If you do not know about the compatibility of chemicals you are considering mixing, it is advisable to check the labels and compatibility charts. Even if the materials are compatible, you should test for potential phytotoxic or staining effects.

Chemical Failures

PCOs are occasionally confronted with callbacks that they believe to be due to chemical failure rather than improper application or reinfestation. Chemical failure may be caused by several factors:

- Research has shown that the physical and chemical natures of treated substrates can reduce the activity and residual life of pesticides.
- Age of the pesticide (how long you have had it on hand and has it been opened?) Some labels indicate how long the formulation remains effective after the container is opened; however, most do not. Check with

your supplier for this information.

- Light effects on certain pesticides (i.e., ultraviolet can cause degradation via chemical transformation).
- Soil effects (e.g., some organophosphates may undergo conversion in soil mainly due to solid and liquid phases in the soil. The soil components can influence reactions such as hydrolysis and phosphorylation).
- Temperature extremes can cause some pesticide products to break down in storage or after application.
- Moisture and humidity can also adversely affect pesticide activity.
- pH of water used in mixing and application (e.g., most carbamates and organophosphates undergo alkaline hydrolysis in alkaline water, thus the higher the pH the faster the decomposition of some pesticides).

Fire – The Explosion Hazard

Turn off all fires and pilot lights before using foggers, oil-base materials through mist blowers, ULV formulations, certain oil sprays and other materials that may be explosive or present a fire hazard. By turning off the gas at the meter, you will extinguish all flames. If oil-base formulations are not practical, use water as the carrier. Oil, solvents and certain other materials form highly flammable or explosive mixtures.

Electrical Safety

Water-base sprays used near electrical boxes and switches are hazardous since water is a good conductor of electricity. Kerosene is a poor conductor and is much safer to use around electrical connectors. When working inside or outside around transformers, be very careful not to spray into them or touch them. When working with electrically powered tools, avoid working on wet ground and use grounded equipment and rubber gloves. The safest measure is to check the circuit with a circuit tester and be sure of the ground before plugging in any power tool. Special care must be taken while working under or around houses when the soil is wet. Inspect electrical tools to be certain they are in proper working order. Some electrical circuits, such as those in older homes and buildings, are not adequate to carry the load of some electrically powered pumps and drills. Under such conditions, you may “knock out” a circuit or create a fire from overheated wiring. Considerable care should be exercised when moving and working around refrigerators, freezers, ranges and other large appliances. Always double check to be certain that you have not accidentally unplugged electrical connections or broken gas lines to appliances.

Customer Safety

When treating inside structures, use great care to avoid contaminating food, food surfaces, utensils, medicines, linens, bedding and other items that customers may contact. Try to avoid treating surfaces that children, workers or animals will contact frequently. Advise customers to keep children and pets off treated surfaces until the spray has dried for at least several hours. Where babies or small children live in the house, the customer should be advised to keep them off treated surfaces for at least two days and to thoroughly vacuum the carpet before allowing children on treated areas. When making outside treatments, advise customers to keep children and pets off treated areas until the spray has dried. Also read the label carefully for possible requirements to water turf before children are allowed on treated areas. Hospitals and nursing homes are sensitive areas where pesticides must be used according to labels and with great care. Consult special regulations and management personnel for accepted practices before treating these types of institutions.

Avoid getting vapors into air handling systems. Take special precautions when treating around babies, the sick, aged and people with allergies or respiratory problems. Do not apply any sprays, mists, aerosols or dusts around or near children. Asthmatics, alcoholics, diabetics and persons who have emphysema may be unusually sensitive to many pesticides. Do not apply sprays, dusts or mists while these individuals are in the room. Be certain that the room (or structure) treated is well ventilated before such persons are allowed to re-enter.

Before making an “initial” treatment, you should require the customer to make proper preparations when the procedure includes treatment of kitchen cabinets and food areas. Never treat over silverware, dishes, exposed food or food in containers that might become contaminated (such as flour sacks or cereal boxes) or under any other condition that might result in contamination or adversely affect the health of customers. Pesticide containers or equipment should not be left unattended in a home or building where children could get to them.

Provide good ventilation to remove pesticide vapors. It is advisable to have people leave the structure on initial heavy treatments, and re-entry time should be at least three to four hours.

Fish are highly sensitive to pesticides. Consequently, no dust, spray or vapors should be allowed to get into aquariums or outside fishponds. Before using spray materials where fish or other aquatic animals are present, either remove the tanks from the area to be treated to cover tanks with plastic or moistened paper. Also the circulating pump should be unplugged and the room adequately ventilated. The aquarium pump may need to be started within two hours to prevent the possibility of the fish dying from lack of oxygen. When treatment is made inside where fish cannot be removed or adequately protected, it is much safer to use baits.

When the water source is a well or a cistern, extreme care needs to be taken to prevent contamination of these water supplies. For perimeter treatments, consult the owner about the drinking water source before treatment is made, especially in rural areas. This is very important since pesticides can move laterally 25 to 30 feet or more in porous soil. Check the label and contact the health officials if there is any question about possible contamination of drinking water supplies.

Every effort must be made to avoid contaminating ponds, lakes, streams or runoff areas draining to waterways. Be careful and avoid spills and leaks near these areas and never empty excess spray or dump pesticide containers near these water sources.

Baits and powders used in homes and food-handling establishments must not be placed in exposed locations where they would be accessible to children and pets or where they could contaminate food. Do not place dusts under refrigerators or in situations where appliances, machinery or wind currents could cause the dust to become airborne.

Baits placed inside grain elevators and food warehouses should be inside metal bait boxes that are permanently secured so that baits cannot accidentally be spilled or otherwise contaminate food or feedstuffs.

When making pesticide applications in food-handling establishments and homes, be especially alert to any requirements for special application techniques and timing and placement of the pesticide.

Decontamination

When accidental spillage of large amounts of pesticides occur, you may need to take quick action to reduce the contamination level of the immediate area. If the spill takes place on the street or highway, notify the Arkansas State Police and keep unauthorized personnel out of the area. Contact your pesticides dealer or supplier for information on clean-up procedures. The following information provides general procedures for cleaning up spills.

Liquids. Confine the spread of toxic materials by damming up with dirt the areas where the spill occurred. Absorb as much of the liquid spill as possible with dirt, cement or other absorptive materials. Place all wastes in barrels that are sealed and properly labeled; then take the material to an approved hazardous waste disposal site or contact a firm that specializes in hazardous waste disposal. Spray the contaminated area with a 50/50 solution of liquid bleach and water. Then spread hydrated lime over the area to absorb the liquid bleach solution. The lime should be left in place for at least one hour before cleaning it up.

Powders and Granules. Take all suitable precautions depending on toxicity of materials and extent of contamination. Sweep up all dusts and shovel into barrels, store, seal and dispose of as described above. Spray down containers and contaminated areas as above. Large or hazardous decontamination jobs should not be attempted without proper knowledge and safety equipment. Notify the Arkansas State Plant Board, the pesticide supplier or the Arkansas Department Health for advice and/or assistance in decontamination problems that you are not qualified to perform. Wear the proper safety equipment and clothing to prevent intoxication by the spilled pesticides.

Contaminated Clothing. Grossly contaminated clothing and shoes should be destroyed. Clothing with slight contaminations should be cleaned as follows: (1) wash alone, (2) use detergent and (3) hang in the sun to dry. If there is residual pesticide odor, repeat the process. Clothes worn for pest control service work should not be washed with family clothes. Babies are extremely sensitive to very small amounts of pesticides, and their clothing or bedding must not become contaminated.

Container and Pesticide Disposal

Pressure or triple rinse empty pesticide containers with water. Pour rinsate into spray solution. Crush, puncture or break the containers. Properly decontaminated containers may be disposed of by recycling or burying in approved sanitary landfills after breaking or puncturing and crushing.

Since many pesticides create contamination problems if not disposed of properly, unused quantities of finished sprays must be placed where no pollution will result. If at all possible, use the pesticide for purposes listed on the label. Do not dispose of pesticides by pouring them down any drain or toilet. If there is doubt about the disposal of unused pesticides in spray tanks or containers, contact the Arkansas State Plant Board.

Recordkeeping

It is essential that an accurate record of each pesticide application be kept. This information will be extremely important in case of poisoning or environmental contamination and is a good business practice. A record of the pesticide used will be helpful in situations where effective control was not achieved. Records should be kept in a field book or on work tickets filled out at the time of pesticide application. These should remain at the principal business location for two (2) years. Information that should be recorded includes:

1. Name and address of applicator.
2. Customer's name and address.
3. Date and time of application.
4. Trade name and registration number of product.
5. Tank mix, dilution rate, and quantity of product.
6. Target pest and use site (e.g., cupboards, drawers, moldings or ornamental shrubs, etc.).
7. Environmental conditions when outside treatments are made (e.g., wind velocity, direction, temperature, etc.).

Emergency Procedures

In case of accidental poisoning of humans or pets, call a physician or veterinarian immediately. Provide medical personnel with the label of the pesticide involved or relay complete information to them on the active ingredients or common name of the pesticide, and all information on first aid treatments as described on the label. Keep the address and phone number of the nearest Poison Control Center in each vehicle and in each office. In this state, contact Poison Hotline (Arkansas Poison Control Center) 1-800-376-4766.

Pesticides, Groundwater and Endangered Species

Learning Objectives:

Upon completion of the study of Pesticides, Groundwater and Endangered Species, the trainee should be able to:

- Know where, how and why pesticides can enter the hydrologic system.
- Understand the differences in pesticide and soil properties.
- Have a general understanding of soil, water and pesticide terms.
- Know how to find out which endangered species may be in the area the applicator is working.

Pesticides and Groundwater

Most of the drinking water in the United States is groundwater; however, Arkansas has numerous lakes and reservoirs and that is where the majority of Arkansans receive their drinking water. Arkansas' rural residents and small communities rely on groundwater for their drinking water sources.

The amount of groundwater affected by pollution (all forms) is about 2 percent in the U.S.; however, an increasing amount of surface water is becoming at least somewhat contaminated (EPA, 1990).

More than 4.5 billion pounds of pesticides are used in the U.S. annually. Of this volume, agriculture accounts for two-thirds of this usage. This includes nursery and greenhouse production systems. The home and garden sector used 135 million pounds of pesticides in 1995 (EPA, 1997).

Pesticides can contaminate water throughout the hydrologic system. The amount of water contamination is directly related to the degree of pollution in our environment. Rainwater flushes airborne pollution from the skies. The pollution is then washed over the land before running into rivers, aquifers and lakes. The pollution also seeps into underground aquifers. Irrigation and drinking water come from both surface and groundwater. Eventually, all chemicals we use can pollute our water supplies.

There are many materials that endanger our water quality. Most come from urban and industrial activity. Some, however, come from agriculture and urban pest control uses. Whether utilized in agricultural operations or in urban environments, the improper application, handling or disposal of pesticides can lead to water pollution. It is very important for the pest control operator to understand how to properly use pesticides to avoid not only pesticide exposure to humans but to protect our water sources.

When selecting pesticides for use in structures, the pesticide applicator needs to be keenly aware of when and where pesticides can enter the hydrologic system. The two primary routes of entry are through drains and exposure to soil or paved surfaces. Regarding soil exposure, the applicator needs to be knowledgeable of the pesticide's water solubility. This can be obtained from the pesticide label and the pesticide's Material Safety Data Sheet (MSDS). Additional water data is often available from the Arkansas State Plant Board, University of Arkansas and the chemical company. An applicator should build their own file on pesticides and water contamination. This will allow the applicator ready access to the information.

Ways Pesticides Can Contaminate Water

Entry via Drains

Structures have drains that go to wastewater treatment plants. These are called sanitary drains and are represented by kitchen sinks, toilets, bathtubs, etc. Pesticides discharged down these drains go directly to the wastewater treatment plant. Many of these pesticides will either disrupt the microorganisms used to break down the sewage or affect the organisms used by the plant as bioassays of the effluent (water released after treatment). In either case, the wastewater treatment plant can be severely limited in the amount of sewage it can treat. When bioassay organisms are affected, the plants are required to either remove the offending pesticide or build plants that can withstand the pesticide(s). The construction of new wastewater treatment plants is extremely expensive and is not a viable option to a contamination problem.

The other drain involved can be the storm drains. These drains are often found in the streets but can be in lawn areas. As their name implies, they drain water from storm events such as rain and melted snow. In most cites, storm drain water is not treated and directed into a drainage system such as a creek or river. Pesticide spills or runoff into storm drains can have environmental affects on aquatic organisms living in the creeks or streams in which the drains deposit.

Entry via Soil

Pesticides used in the General Pest category can be exposed to soil by spills or direct application to the perimeter of the structure. In both cases, the applicator needs to be knowledgeable of the pesticide's ability to move with water, either down or over the soil surface. As mentioned above, this information is often found on the pesticide's MSDS. The applicator must also be aware of drainage systems around a structure's foundation. Often there are French drains or other systems employed to move water away from the foundation. These drainages will also move a pesticide that leaches into the drain.

Improperly cleaning pesticide containers and sprayers often leads to pesticide runoff or contamination of the soil at the mixing/loading site. Pesticide sprayers should be loaded and cleaned on an impervious pad. By mixing/loading and cleaning a sprayer on an impervious pad, there is not a concern about spills causing runoff or leaching problems. This avoids the potential contamination of the soil and nearby wells from constant small spillages at the same site.

When filling any sprayer, either an air gap or an anti-back siphoning device is to be used. This prevents back siphoning of the pesticide mix into the water line if water pressure is lost. If using anti-back siphoning devices, periodically inspect the device to ensure it is functioning properly. Mechanical back siphoning devices have been known to stick in the open position.

Pesticide containers should be pressure or triple rinsed immediately after emptying to rinse all excess pesticide from the container. The rinsate is to be rinsed directly into the sprayer so the rinsate can be sprayed on the labeled site. This provides a clean container that can then be recycled.

Pesticide Properties

The applicator must know the type of pesticide and its properties prior to purchasing and using the pesticide. This is an extremely important aspect to know. The applicator needs to know the pesticide's formulation, persistence, volatility, solubility in water and its soil adsorption.

Formulation

Pesticides come in several physical forms or formulations. Common formulations include emulsifiable and flowable concentrates, wettable powders, granules, and water dispersible granules. Granules, water dispersible granules and emulsifiable concentrates tend to be more water-soluble than wettable powders and microencapsulated formulations.

Persistence

Persistence describes how long a pesticide remains active. Half-life is one measure of persistence. The half-life of a substance is the time required for that substance to degrade to one-half its original concentration. In other words, if a pesticide has a half-life of 10 days, half of the pesticide has been broken down or lost 10 days after application. After this time, the pesticide continues to breakdown at the same rate. The half-life of a pesticide is not an absolute factor. Soil moisture, temperature, organic matter, microbial activity, soil pH and sunlight all affect the breakdown of pesticides. In general, the longer a pesticide persists in the environment, the more likely it is to move from one place to another and be a potential water contaminant.

Volatility

Many pesticides including several herbicides and soil fumigants can escape from soils/medias as gases. Some can distill from soil and enter the atmosphere with evaporating water. Pesticide particles in the atmosphere can come back to earth in rain or snow, and they can either leach into groundwater or be carried by runoff into surface water.

Water Solubility

The water solubility of a pesticide determines how easily it goes into solution with water. When a pesticide goes into solution with water, the pesticide will move wherever the water goes. Solubility is usually given in parts per million (ppm) or, in some cases,

as milligrams per liter (mg/l). The solubility of a substance is the maximum number of milligrams that will dissolve in one liter of water.

Simply being water-soluble does not mean that a pesticide will leach into groundwater or runoff into surface water. However, solubility does mean that if a soluble pesticide somehow gets into water, it will probably stay there and go where the water goes. Water solubility is often viewed as an indicator of the pesticide's mobility in water. Water solubility and adsorption to soil particles for most compounds are inversely related. However, like most rules there are exceptions. Water solubility greater than 30 ppm indicates that significant mobility is possible if the K_{oc} value is low (less than 300-500). EPA considers pesticides with solubility greater than 30 ppm and K_{oc} values less than 100 to be a concern in sandy soil.

Pesticides with solubilities of 1 ppm or less are believed to have a higher likelihood of runoff. Likewise, pesticides with high ~ values have a higher likelihood of runoff than leaching. Pesticides with K_{oc} values of 1,000 or higher have a strong soil attachment.

Soil Adsorption

Soil adsorption is the tendency of materials to attach to the surfaces of soil particles. If a substance is adsorbed by the soil, the substance stays on or in the soil and is less likely to move into the water system unless soil erosion occurs. A soil's texture, structure and organic matter content affect the soil's ability to adsorb chemicals.

The K_{oc} describes the relative affinity or attraction of the pesticide to soil material and, therefore, the pesticide's mobility in soil. Pesticides with small K_{oc} values are more likely to leach than those with high K_{oc} values.

How Pesticides Enter Surface and Groundwater

Pesticides can enter water through surface runoff, leaching and/or erosion. Water that flows across the surface of the land – whether from rainfall, irrigation or other sources – always flows downhill until it meets a barrier, joins a body of water or begins to percolate into the soil.

Wind and water can erode soil that contains pesticide residues and carry them into nearby bodies of water. Even comparatively insoluble pesticides and pesticides with high soil adsorption properties can move with eroding soil. A number of the sulfonylurea herbicides have warning statements regarding movement of treated soil.

With increasing frequency, soil applied pesticides are being found in groundwater where the water table is close to the soil surface and/or the soil is a sand.

Point and Non-Point Source

Pesticides that enter water supplies can come either from point sources or from non-point sources. Point sources are small, easily identified objects or areas of high pesticide concentration such as tanks, mixing/loading sites at wellheads, containers, or spills. **Non-point sources** are broad, undefined areas in which pesticide residues are present.

Water Quality Protection

Most pesticide contamination does not come from normal, correct usage. Problems arise from misuse or careless handling. A checklist is provided to use when applying any pesticide. Use this guideline to help safeguard water sources near your accounts.

- Consider vulnerability of the site; be sure that weather and irrigation will not increase the risk of water contamination.
- Evaluate the location of water sources.
- Read and follow pesticide label directions.
- When possible use pesticides with less potential for surface runoff and leaching.
- Store pesticides properly.
- Make sure pesticide containers do not leak.
- Use IPM practices.
- Calibrate all pesticide application equipment at least after every third use.
- Prevent back flow during mixing operations by use of an air gap or mechanical anti-siphoning device.
- Pressure or triple rinse pesticide containers upon emptying and pour rinsate into spray tank.
- Always mix, handle and store pesticides down slope and at least 50 feet from water wells.
- Do not apply pesticides when conditions are most likely to promote runoff or excessive leaching.

Table 10-1. Insecticide Water Quality Data			
Insecticide Common Name	**Relative Runoff Potential**	**Relative Groundwater Leaching Potential**	**Half-Life in Days**
Diazinon	Medium	Large	30
Acephate	Low	Low	3
Chlorpyrifos	Large	Small	30
Carbaryl	Medium	Small	10
Malathion	Small	Small	1

- Do not spray pesticides on windy days (winds in excess of 10 mph).
- Prevent pesticide spills and leaks from application equipment.
- Do not water pesticide treated areas immediately after application unless indicated on label instructions.
- Dispose of excess pesticides by applying them to labeled sites.

Note: See glossary for more detailed description of soil, water and pesticide terms.

Endangered Species

Applicators in the General Pest category should not encounter federally threatened or endangered species inside structures; however, you may encounter them outside structures.

The Endangered Species Protection Program started in 1988. It is largely voluntary at the present time and relies on co-operation between the U.S. Fish and Wildlife Service (USFWS), EPA regions, the states and pesticide users. Arkansas has a voluntary Endangered Species Protection Program with bulletins for 30 counties, which is on the EPA web site (http://www.epa.gov/espp/usa-map.htm). A user can go to this site and get information about an endangered species habitat found in their area. This information can be found on pesticide labels if the products being used will cause harm to the endangered species or its habitat.

The Endangered Species Act is intended to protect and promote the recovery of animals and plants that are in danger of becoming extinct due to the activities of people. Under the Act, EPA must ensure that the use of pesticides it registers will not result in harm to the species listed as endangered and threatened by the U.S. Fish and Wildlife Service, or to habitat critical to those species' survival. To implement the Endangered Species Protection Program, labels of certain pesticides will direct users to bulletins with information on the endangered species habitat. This program will protect endangered and threatened species from harm due to pesticides use.

The Endangered Species Protection Act has two goals:

1. Provide best protection for endangered species from the use of pesticides.
2. Minimize the impact of the EPA's Endangered Species Protection Program on pesticide users.

This program will be successful if everyone will follow information found on the pesticide labels.

It is the applicator's responsibility to know which species may be in the area the applicator is working. In Arkansas, most of the federally threatened and endangered species occur outside of towns and cities.

Applicators may cause harm to these species through pesticide spills, runoff or leaching. It is highly unlikely that one perimeter application would cause an adverse affect to an endangered species; however, multiple perimeter treatments that find their way into water systems could affect certain species.

Once again, it is the applicator's responsibility to know if a threatened or endangered species is within the area. An applicator can obtain this information from the Arkansas County Extension offices, Pesticide Coordinator's office, Arkansas State Plant Board and Arkansas Wildlife Conservation offices.

Table 10-2. Arkansas Endangered/Threatened Animal and Plant Species – Total 29	
Animals – 23 species	
Status	**Animal**
T	Alligator, American (*Alligator mississippiensis*)
E	Bat, gray (*Myotis grisescens*)
E	Bat, Indiana (*Myotis sodalis*)
E	Bat, Ozark big-eared (*Corynorhinus (=Plecotus) townsendii ingens*)
E	Beetle, American burying (*Nicrophorus americanus*)
T	Cavefish, Ozark (*Amblyopsis rosae*)
E	Crayfish, cave (*Cambarus aculabrum*)
E	Crayfish, cave (*Cambarus zophonastes*)
T	Darter, leopard (*Percina pantherina*)
T	Eagle, bald (lower 48 states) (*Haliaeetus leucocephalus*)
T	Fatmucket, Arkansas (*Lampsilis powelli*)
E	Mapleleaf, winged (mussel) Entire; except where listed as experimental populations (*Quadrula fragosa)*
E	Mucket, pink (pearlymussel) (*Lampsilis abrupta*)
E	Mussel, scaleshell (*Leptodea leptodon*)
E	Pearlymussel, Curtis (*Epioblasma florentina curtisii*)
E	Pocketbook, fat (*Potamilus capax*)
E	Pocketbook, Ouachita rock (*Arkansia wheeleri*)
E	Pocketbook, speckled (*Lampsilis streckeri*)
T	Shagreen, Magazine Mountain (*Mesodon magazinensis*)
T	Shiner, Arkansas River (Arkansas R. Basin) (*Notropis girardi*)
E	Sturgeon, pallid (*Scaphirhynchus albus*)
E	Tern, least (interior pop.) (*Sterna antillarum*)
E	Woodpecker, red-cockaded (*Picoides borealis*)
Plants – 6 species	
Status	**Plant**
T	*Geocarpon minimum* (No common name)
E	Bladderpod, Missouri (*Lesquerella filiformis*)
E	Pondberry (*Lindera melissifolia*)
T	Orchid, eastern prairie fringed (*Platanthera leucophaea*)
E	Harperella (*Ptilimnium nodosum*)
E	Clover, running buffalo (*Trifolium stoloniferum*)

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Glossary

absorb. To soak up or take in liquid or powder.

absorption. The movement of a chemical into plants, animals (including humans) and microorganisms.

accumulate. To increase in quantity within an area, such as the soil or tissues of a plant or animal.

active ingredient (a.i.). The material in the pesticide formulation that actually destroys the target pest or performs the desired function.

adsorb. To take up and hold on surface.

adsorption. The process by which chemicals are held or bound to a surface by physical or chemical attraction. Clay and high organic soils tend to adsorb pesticides.

adsorption characteristics (K_{oc}). The ~ describes the relative affinity or attraction of the pesticide to soil material and, therefore, its mobility in soil. Pesticides with small ~ values are more likely to leach than those with high K_{oc} values.

aerosol. Very fine liquid droplets or dust particles often emitted from a pressurized can or aerosol-generating device.

agitator. A mechanical or hydraulic device that stirs the liquid in a spray tank to prevent the mixture from separating or settling.

anti-siphoning device. A device attached to the filling hose that prevents backflow or back siphoning from a spray tank into a water source.

anticoagulant. A type of rodenticide that causes death by preventing normal blood clotting.

arachnid. A wingless arthropod with two body regions and four pairs of jointed legs. Spiders, ticks and mites are in the class Arachnida.

arthropod. An animal having jointed appendages and an external skeleton, such as an insect, a spider, mite, crab or centipede.

attractant. A substance that attracts a specific species of animal. When manufactured to attract pests to traps or poisoned bait, attractants are considered pesticides.

avicide. A pesticide used to control pest birds.

bacterium (plural: bacteria). A unicellular, microscopic, plantlike organism that lives in soil, water, organic matter or the bodies of plants and animals. Some bacteria cause plant or animal diseases.

bait. A food or food-like substance that is used to attract and often poison pest animals.

bioaccumulation. The storage or accumulation of materials in the tissues of living organisms.

biological control. The action of parasites, predators, pathogens or competitors in maintaining another organism's density at a lower average than would occur in their absence. Biological control may occur naturally in the field or be the result of human manipulation or introduction of biological control agents.

calibration. Measurement of the output of pesticide-application equipment so that the proper amount of pesticide can be applied to a given area.

carbamates (N-Methyl Carbamates). A group of pesticides containing nitrogen, formulated as insecticides, fungicides and herbicides. The N-Methyl Carbamates are insecticides and inhibit cholinesterase in animals.

carcinogenic. Cancer producing.

carrier. The liquid or powdered inert substance that is combined with the active ingredient in a pesticide formulation. May also apply to the water or oil that a pesticide is mixed with before application.

chemical control. Pesticide application to kill pests.

chlorinated hydrocarbon. A pesticide containing chlorine, carbon and hydrogen of which many are persistent in the environment. Examples: chlordane, DDT, methoxychlor.

commercial applicator. A certified applicator that, for compensation, uses or supervises the use of any pesticide classified for restricted use for any purpose or on any property other than that producing an agricultural commodity.

compatible. The condition in which two or more pesticides mix without unsatisfactory chemical or physical changes.

concentration. Refers to the amount of active ingredient in a given volume or weight of formulated product.

confined area. Enclosed spaces such as attics, crawl spaces, closed rooms, warehouses, greenhouses, holds of ships and other areas that may be treated with pesticides.

contamination. The presence of an unwanted substance (sometimes pesticides) in or on a plant, animal, soil, water, air or structure.

coverage. The degree to which a pesticide is distributed over a target surface.

decontaminate. To remove or break down a pesticidal chemical from a surface or substance.

degradation. Degradation occurs due to sunlight, soil microorganisms and chemical reactions in the soil. Soil temperature and moisture can greatly affect degradation. Degradation rate is quantified in terms of degradation half-life, the time required for 50% of the pesticide to decompose to products other than the original pesticide. EPA considers a soil half-life of greater than 21 days as a pesticide with potential for causing water concerns due to the pesticide's longevity.

deposit. The placement of pesticides on target surfaces.

desiccant. A pesticide that destroys target pests by causing them to lose body moisture.

diagnosis. The positive identification of a problem and its cause.

diluent. Any liquid or solid material used to dilute or weaken a concentrated pesticide.

disease. A condition, caused by biotic or abiotic factors, that impairs some or all of the normal functions of a living organism.

dissolve. To pass into solution.

dose. The measured quantity of a pesticide. Often the size of the dose determines the degree of effectiveness, or, in the case of poisoning of nontarget organisms, the degree of injury.

drift. The movement of pesticide dust spray or vapor away from the application site.

dust. Finely ground pesticide particles, sometimes combined with inert materials. Dusts are applied without mixing with water or other liquid.

emulsifiable concentrate. A pesticide formulation consisting of a petroleum-based liquid and emulsifiers that enable it to be mixed with water for application.

emulsion. A mixture of two liquids that is not soluble in one another. One is suspended as very small droplets in the other with the aid of an emulsifying agent.

endangered species. Rare or unusual living organisms whose existence is threatened by people's activities, including the use of some types of pesticides.

environment. All of the living organisms and nonliving features of a defined area.

Environmental Protection Agency (EPA). The federal agency responsible for regulating pesticide use in the United States.

EPA registration number. An identification number assigned to a pesticide product when the product is registered by the EPA for use. The number must appear on all labels for a particular product.

eradication. The pest-management strategy that attempts to eliminate all members of a pest species from a defined area.

exclusion. Pest management technique that uses physical or chemical barriers to prevent certain pests from getting into a defined area.

exposure. Coming in contact with a pesticide.

FIFRA. Federal Insecticide, Fungicide, and Rodenticide Act; a federal law and its amendments that control pesticide registration and use.

flowable. A pesticide formulation of finely ground particles of insoluble active ingredient suspended in a petroleum-based liquid combined with emulsifiers; flowables are mixed with water for final application.

flypaper. Strips of paper coated with a sticky substance and sometimes a pheromone attractant hung in areas inside buildings where flies are a problem. Flies become entangled in the sticky substance.

fog. A spray of very small pesticide-laden droplets that remains suspended in the air.

formulation. A mixture of active ingredients combined during manufacture with inert materials. Inert materials are added to improve the mixing and handling qualities of a pesticide.

fumigant. Vapor or gas form of a pesticide used to penetrate porous surfaces for control of soil-dwelling pests or pests in enclosed areas or storage.

fungicide. A pesticide used for control of fungi.

fungus (plural: fungi). A group of small, often microscopic, organisms in the plant kingdom, which cause rot, mold and disease. Fungi need moisture or a damp environment (wood rots require at least 19 percent moisture). Fungi are extremely important in the diet of many insects.

glueboard. A small cardboard sheet or boxlike apparatus having one or more surfaces coated with a thick, sticky paste. This is placed on surfaces to capture pest insects or small rodents.

granule. A dry formulation of pesticide active ingredient and inert materials compressed into small, pebble-like shapes.

groundwater. Fresh water trapped in aquifers beneath the surface of the soil; one of the primary sources of water for drinking, irrigation and manufacturing.

habitat. The place where plants or animals live and grow.

habitat modification. A pest management practice that involves modifying certain physical aspects of a building or structure to make it less suitable for pests to live.

host. A plant or animal species that provides sustenance for another organism.

impregnate. An item, such as a flea collar, that has been manufactured with a certain pesticide in it; impregnates usually emit small, localized quantities of pesticide over an extended period of time.

incompatibility. A condition in which two or more pesticides are unable to mix properly or one of the materials chemically alters the other to reduce its effectiveness or produce undesirable effects on the target.

inhalation. The method of entry of pesticides through the nose or mouth into the lungs.

insect growth regulator (IGR). A type of pesticide used for control of certain insects. IGRs disrupt the normal process of development from immature to mature life stages.

insecticide. A pesticide used for the control of insects. Some insecticides are also labeled for control of ticks, mites, spiders and other arthropods.

insects, Insecta. A class in the phylum Arthropoda characterized by a body composed of three segments and three pairs of legs.

inspection. The thorough checking of items for the presence of pests or pest eggs before bringing the items into a pest-free area.

integrated pest management (IPM). A pest management program that uses life-history information and extensive monitoring to understand a pest and its potential for causing economic damage. Control is achieved through multiple approaches including prevention, cultural practices, pesticide applications, exclusion, natural enemies and host resistance. The goal is to achieve long-term suppression of target pests with minimal impact on nontarget organisms and the environment.

knockdown. An insecticide that has a rapid, although sometimes temporary, immobilizing effect on target insects; some knockdown materials have rapid killing abilities.

label. All printed material attached to or on a pesticide container.

labeling. The pesticide product label and other accompanying materials that contain directions that pesticide users are legally required to follow.

larva (plural: larvae). The immature form of insects that undergo complete metamorphosis.

leaching. The process by which some pesticides move down through the soil, usually by being dissolved in water, with the possibility of reaching groundwater.

material safety data sheet (MSDS). An information sheet provided by a pesticide manufacturer describing chemical qualities, hazards, safety precautions and emergency procedures to be followed in case of a spill, fire or other emergency.

metamorphosis. The more or less sudden physical transformation undergone by insects (and some other animals) during their development; the change of an insect from egg to nymph to adult or from egg to larva to pupa to adult.

monitoring. The process of carefully watching the activities, growth and development of pest organisms over a period of time, often using very specific procedures.

MSDS. Material safety data sheet.

nymph. The developmental stage of insects with gradual metamorphosis that hatches from the egg. Nymphs become adults.

ootheca (plural: oothecae). A capsule, constructed by female cockroaches, into which they deposit many eggs; some species carry an ootheca attached to the body, while others will deposit the ootheca in a hidden place.

organism. Any living thing.

organophosphates. A large group of pesticides that contain the element phosphorus and inhibit cholinesterase in animals.

parasite. A plant or animal that derives all its nutrients from another organism. Parasites often attach themselves to their host or invade the host's tissues. Parasitism may result in injury or death of the host.

penetrate. To pass through a surface such as skin, protective clothing, plant cuticle or insect cuticle. Also refers to the ability of an applied spray to pass through dense foliage.

persistence. The ability of a substance to remain in its original form without breaking down.

pest. An undesirable organism: (1) any insect, rodent, nematode, fungus, weed or (2) any other form of terrestrial or aquatic plant or animal life or virus, bacteria, or other microorganism (except viruses, bacteria, or other microorganisms on or in living man or other living animals) which the administrator declares to be a pest under FIFRA, Section 25(c)(I).

pesticide. Any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any insects, rodents, nematodes, fungi or weeds, or any other forms of life declared to be pests; and any other substance or mixture of substances intended for use as a plant regulator, defoliant or desiccant.

pesticide formulation. The pesticide as it comes from its original container, consisting of the active ingredient blended with inert materials.

pH. A measure of the acidity/alkalinity of a liquid: acid below pH 7; basic or alkaline above pH 7 (up to 14). A pH of 7 is neutral.

pheromone. A chemical produced by an animal to attract other animals of the same species.

physical control. Habitat alteration or changing the infested physical structure; e.g., caulking holes, cracks, tightening around doors, windows, moisture reduction, ventilation, etc.

physiological. Pertaining to the functions and activities of living tissues.

Poison Control Center. A local agency, generally a hospital, which has current information as to the proper first aid techniques and antidotes for poisoning emergencies. Centers are listed in telephone directories.

population. Individuals of the same species. The populations in an area make up a community.

powder. A finely ground dust container active ingredient and inert materials.

prebaiting. Placing nontoxic bait in a trap to overcome bait or trap shyness on the part of the target pest; once the target pest becomes used to feeding from the trap, the nontoxic bait is replaced with toxic bait.

predator. An animal that attacks, kills and feeds on other animals. Examples of predaceous animals are hawks, owls, snakes and many insects.

pupa (plural: pupae). The developmental stage of insects with complete metamorphosis where major changes from the larval to the adult form occur.

pyrethrins. The active ingredients of pyrethrum insecticides.

rate. The quantity or volume of liquid spray, dust or granules applied to an area over a specified period of time.

re-entry interval. The length of time following a pesticide application when entry into the treated area is restricted.

repellent. A pesticide used to keep target pests away from a treated area by saturating the area with an odor that is disagreeable to the pest.

residual pesticides. A pesticide that continues to remain effective on a treated surface or area for an extended period following application.

residue. Traces of pesticide that remain on treated surfaces after a period of time

resistance. The ability of a host plant or animal to ward off or resist attack by pests or to be able to tolerate damage caused by pests.

rodenticide. A pesticide used for control of rats, mice, gophers, squirrels and other rodents.

runoff. The liquid spray material that drips from the foliage of treated plants or from other treated surfaces. Also, the rainwater or irrigation water that leaves an area; this water may contain trace amounts of pesticide.

sanitation. A pest management practice that involves removing desirable food and habitat that could be used by and promote particular pests.

signal word. The word “Danger,” “Warning” or “Caution” appearing on a pesticide label that signifies how toxic the pesticide is and to what toxicity category it belongs.

soil permeability. Permeability is a function of soil texture, structure and pore space. Highly permeable, coarse, sandy soils have large pores that allow water and pesticides to move rapidly between soil particles during rainfall or irrigation. Medium and fine-textured soils, water moves more slowly, allowing more time for pesticide adsorption and degradation. Each layer of soil can have a different permeability, but the overall permeability is determined by the most restrictive layer. Soil permeability can be enhanced by the presence of macropores, large channels produced by plant roots, earthworms, soil cracks and the burrowing of smaller animals.

soil organic matter. Soil organic matter helps to bind pesticides, especially those with high K_{OC} values and promotes degradation.

soil texture. Permeability and chemical adsorption are both affected by soil texture. Texture is determined by the reactive proportion of sand, silt and clay.

soil pH. The pH of the soil is a measure of its degree of acidity or alkalinity. pH affects the degradation rate of pesticides and the adsorption characteristics and mobility of ionic pesticides.

slope and landscape. Areas with high runoff capability will have less of an impact on water infiltration than areas that are flat or have a concave slope. Landscape that encourages runoff will minimize leaching. Landscape which holds water may increase leaching potential or may provide organic matter which assists in “holding” the pesticide.

soluble. A material that dissolves completely in a liquid.

solution. A liquid that contains dissolved substances, such as a soluble pesticide.

solvent. A liquid capable of dissolving certain chemicals.

sorptive dust (or powder). A fine powder used to destroy arthropods by removing the protective wax coating that prevents water loss.

space spray. A pesticide that is applied as a fine spray or mist to a confined area.

spot treatment. A method of applying pesticides only in small, localized areas where pests congregate rather than treating a larger, general area.

suppress. To lower the level of a pest population.

surface water. Water found in ponds, lakes, reservoirs, streams and rivers.

suspension. Fine particles of solid material distributed evenly throughout a liquid such as water or oil.

target. Either the pest that is being controlled or surfaces within an area that the pest will contact.

tolerance. The ability to endure the effects of a pesticide or pest without exhibiting any adverse effects.

total release. A pressurized insecticide dispenser that will release its entire contents into an area once it has been triggered.

toxic. Poisonous to living organisms.

toxicant. A poisonous substance such as the active ingredient in a pesticide formulation.

toxicity. The potential a pesticide has for causing harm.

toxin. A naturally occurring poison produced by plants, animals or microorganism; examples, the poison produced by the black widow spider, the venom produced by snakes, the botulism toxin.

tracking powder. A fine powder that is dusted over a surface to detect or control certain pests such as cockroaches or rodents. For control, the inert powder is combined with a pesticide; the animal ingests this powder and becomes poisoned when it cleans itself.

urban. A standard metropolitan area or a town of 2,500(+) occupants.

use. The performance of pesticide-related activities requiring certification include application, mixing, loading, transport, storage or handling after the manufacturing seal is broken; care and maintenance of application and handling equipment; and disposal of pesticides and their containers in accordance with label requirements. Uses not needing certification are long-distance transport, long-term storage and ultimate disposal.

vapor pressure. The property that causes a chemical to evaporate. The higher the vapor pressure, the more volatile the chemical or the easier it will evaporate.

vector. A carrier, and animal (e.g., insect, nematode, mite) that can carry and transmit a pathogen from one host to another.

vertebrate. Animal characterized by a segmented backbone or spinal/column.

virus. Ultramicroscopic parasites composed of proteins. Viruses can only multiply in living tissues and cause many animal and plant diseases.

volatility. The degree to which a substance changes from a liquid or solid state to a gas at ordinary temperatures when exposed to air.

water table. The upper level of the water saturated zone in the ground.

water solubility. A pesticide's water solubility is often viewed as an indicator of its mobility in water. Water solubility and adsorption to soil particles, for most compounds, are inversely related. However, like most rules there are exceptions. Water solubility greater than 30 ppm indicates that significant mobility is possible if the K_{oc} value is low (less than 300 to 500). EPA considers pesticides with solubility greater than 30 ppm and K_{oc} values less than 100 to be a concern in sandy soils.

Pesticides with solubilities of 1 ppm or less are believed to have a higher likelihood of runoff. Likewise, pesticides with high K_{oc} values have a higher likelihood of runoff than leaching. Pesticides with K_{oc} values of 1,000 or higher have a strong attachment to soil.

Solubility is measured in mg/l of the pesticide in water at room temperature (20 or 25 degrees C). It is generally the solubility of the pure (active ingredient) not the formulated product.

wettable powder. Pesticide formulation consisting of an active ingredient that will not dissolve in water combined with a mineral clay and other inert ingredients and ground into a fine powder.

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