General and Household Pest Management Category 7A

Iowa Commercial Pesticide Applicator Manual

IOWA STATE UNIVERSITY
Extension and Outreach

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About this Manual

This manual was prepared for use in Iowa pesticide applicator training programs. It is intended to provide the information needed to meet the minimum U.S. Environmental Protection Agency and Iowa Department of Agriculture and Land Stewardship (IDALS) standards for certification of commercial pesticide applicators under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). This manual also is intended to prepare prospective applicators for an examination, administered by IDALS. It is intended for use as a supplement to the Iowa Core Manual (IC 445).

This manual does not provide all of the information you need for safe and effective use of pesticides. Carefully read and understand the product label for each pesticide you intend to use. Labels list directions, precautions, and health information. **If information on a current pesticide label conflicts with information in this manual, follow the label.** In addition, pesticide manufacturers supply information about products registered for use in Iowa.

Acknowledgments

This manual was revised using information from two resources. Thanks to the following for allowing use of these publications:

University of Kentucky, Cooperative Extension Service Publication ENT-63, Public Health Pest Management, 2005, Michael F. Potter and G. Mark Beavers; 46 pages including additional information

University of Nebraska-Lincoln Extension Publication Structural/Health Related Pest Control, 2010; Clyde Ogg, Renee Lanik, and Vicki Schroeder; 226 pages

This work was prepared by Mark H. Shour, Program Specialist with the Pest Management and the Environment Program, and Donald R. Lewis, Professor and Entomologist, Iowa State University Extension and Outreach.

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General and Household Pest Management

Category 7A

Iowa Commercial Pesticide Applicator Manual

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Introduction

Bold text indicates a word/concept defined in the Glossary of this manual. The number after each glossary term represents the chapter in which the term is found.

Purpose of this Manual

Household pests cause damage to our food, health, and property, and cost billions of dollars annually. Losses resulting from insect and rodent damage to stored food alone exceed $1 billion each year. Pests may also transmit disease, such as food poisoning and gastroenteritis. Other pests bite, sting, or cause allergic reactions in the indoor environment. Lastly, pests living in and around buildings are objectionable to most people by their presence, detracting from the overall quality of life (Figure Intro.1).

The purpose of this manual is to provide general information on the most common household pests, their biology, and current management techniques. Persons likely to utilize this resource include commercial and institutional managers, food plant sanitarians, and others responsible for the management and elimination of household pests, such as cockroaches, ants, bed bugs, stored product, accidental invader, and vertebrate pests.

This manual was designed to assist individuals in preparing for the certification examination in Category 7A, General and Household Pest Management. Information in this manual will supplement that of the Iowa Core Manual (IC 445), with specific information on pesticide safety, the environment, and equipment and application techniques. This manual should not be used for certification purposes without reference to the Iowa Core Manual.

Exam questions were written largely from chapter learning objectives. A few questions are based on content in the Iowa Core Manual to meet federal certification standards. Additional study help is provided in Appendix A.

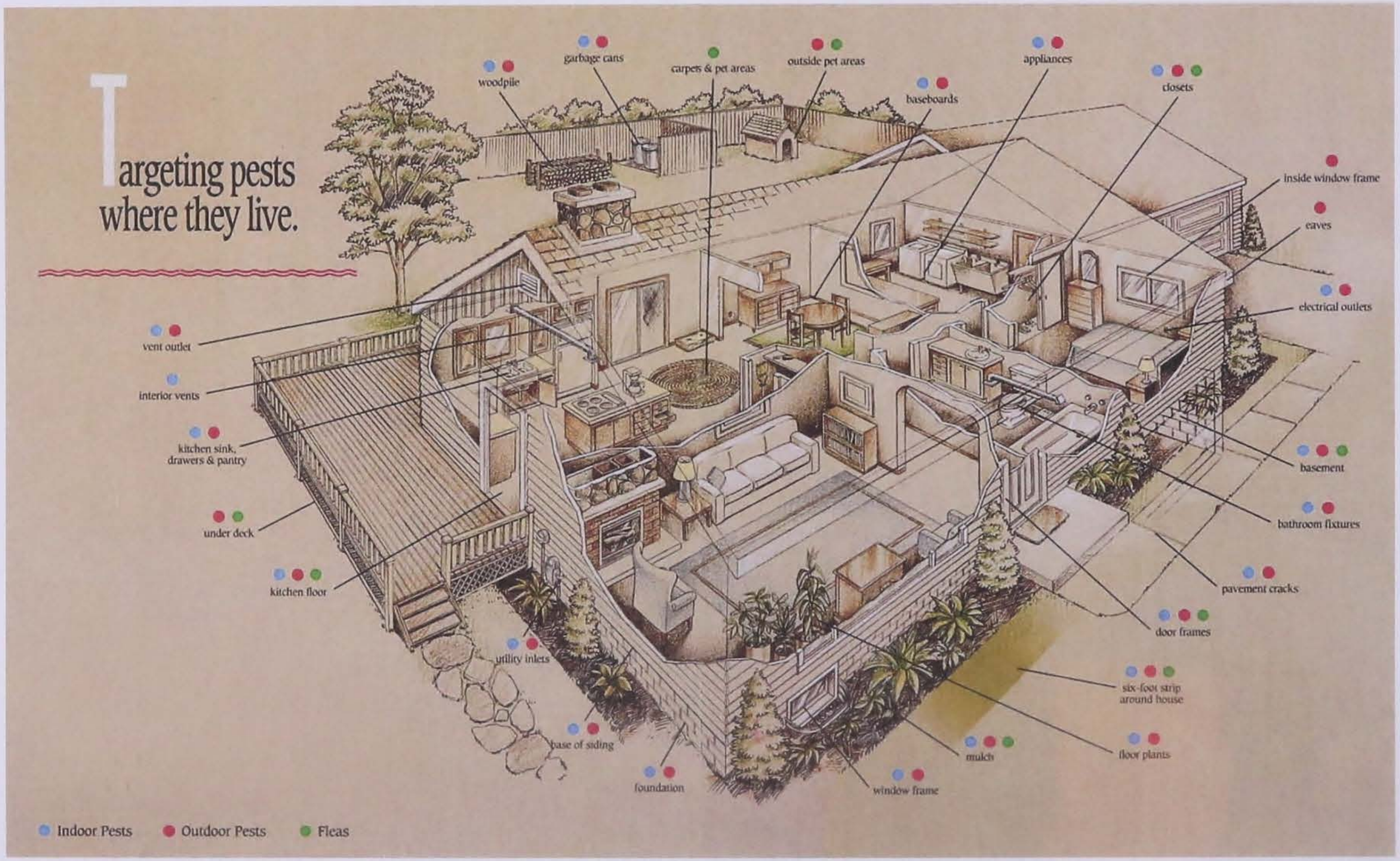


Figure Intro.1. Various places where general and household pests can be found in a structure. Image credit: www.ipcpest.com

Chapter 1
Integrated Pest Management

Learning Objectives

After studying this chapter, you should be able to

- Define: integrated pest management, threshold, harborage, bait
- Tell the difference between gradual and complete metamorphosis
- Identify four places to inspect to look for pests or evidence of pest activity
- List five tools needed during a facility inspection
- List several monitoring techniques used in pest management
- Give examples of food handling establishments requiring pest control
- Distinguish between the following treatment types: spot and crack-and-crevice; void and space; barrier and bait

A Systematic Approach

Integrated Pest Management (IPM) is a systematic approach to pest control that uses all reasonable pest control methods in an environmentally compatible and economically feasible manner to reduce or eliminate pest populations. This approach is often called urban pest management when used in household, commercial, and institutional settings.

Successful implementation of IPM requires the pest management professional (**PMP**) to have a thorough understanding of:

- pests that are likely to be found in the setting;
- pest life cycles and habits;
- reasons why pests are present and flourishing;
- action thresholds for each pest; and
- effective and legal methods to manage pests.

Action thresholds mark the highest acceptable point a pest population can reach without risk of significant damage, health concerns, or nuisance. In structures and domestic dwellings, the primary attitude toward action thresholds is that one insect or rodent is an indicator of additional unseen pests and all are viewed as being out of place. Therefore, the cultural threshold that you often must strive for is complete elimination of all pests from the site.

Pest Identification

Proper pest identification is key to successful pest management. If you cannot readily identify a pest, preserve the pest (if possible) in a plastic container, take a picture, and/or take specific notes. Make an initial identification by using reference books (e.g., Mallis, PCT field guides) or one of the many Internet websites for pest identification (e.g., PestWorld, BugGuide, ID Source). Contact your company for assistance in positive identification.

If further help is needed, the county extension offices in your state can direct the information to a university specialist. As an example, in Iowa samples are sent to The Plant and Insect Diagnostic Clinic at Iowa State University (327 Bessey Hall, Ames, IA 50011) or pictures are emailed to insects@iastate.edu.

Insect Biology

Insects are animals with six jointed legs and three body regions (head, **thorax**, and **abdomen**). Some insects have no wings, while others have two or four wings. For the insects discussed in this manual, mouthparts are either chewing (to bite and tear food) or piercing-sucking (to force into an animal to draw out blood).

Nearly all insects change their shape, form, and size during their life. This change is called **metamorphosis**. One type of change that is gradual, involving little more than an increase in size is referred to as **gradual metamorphosis**. For this type of change, there are three life stages: egg, **nymph**, and adult. Nymphs look like small adults, but lack wings and developed sexual organs.

Other insects represented in this manual go through **complete metamorphosis**. This type of change involves four life stages: egg, **larva**, **pupa**, and adult. The larval stage may be called a caterpillar, grub, or **maggot**. It is usually the larval stage that causes the most damage. When full grown, the larva changes into a pupa, a non-eating stage during which the adult insect is formed.

Site Inspection and Monitoring

The site inspection is a priority of an IPM program (Figure 1.1). You are looking for three things during this inspection:

- signs of pests and damage;
- presence of food, water, and harborage needed by the pest; and
- routes of pest access to those life-supporting needs.

Take detailed notes (including maps of the layout of the structure) during the site inspection. Your notes and diagrams will form the basis for customizing a management program.

Keep pest behavior in mind as you are inspecting. Rodents and cockroaches spend little time away from cover. You will need to look in cracks and crevices, behind/under appliances, in cluttered areas, and along utility lines (electric, water, gas, computer, etc.) where they penetrate the outside building structure or interior walls. The harder a spot is to inspect, the more likely it is that pests will be there.

Figure 1.1. IPM inspections. Image Credit: (A) Erin Bauer, University of Nebraska-Lincon; (B) www.eagle.com.au

Both indoor and bordering outdoor areas should be inspected. Night inspections may be helpful in understanding the pest dynamics at the site. Although the initial visit to the building requires more time, repeat visits are generally faster and allow you to focus on known problem areas, discover new problems, and see that your recommendations are being implemented.

Customer relations are critical during the inspection process. Inspections of private spaces (e.g., cabinets, dressers, desks) may make occupants feel uncomfortable. Take the time to explain what an inspection involves, what you are looking for, and why you need complete access to the site.

Tools that you will need for site inspections include (Figure 1.2):

- Powerful flashlight
- Ultraviolet (black) light
- Magnifying glass/hand lens
- Long-handled mirror (purchased at auto parts store)
- Palette knife or spatula
- Access tools (e.g., screwdrivers, pliers)
- Protective equipment (e.g., safety glasses, knee pads, bump hat, gloves)
- Vacuum with HEPA filter
- Clipboard with paper and pen

Figure 1.2. Example of an IPM inspection kit. Image credit: Erin Bauer, University of Nebraska-Lincoln

Following a detailed site inspection, **monitoring** will allow you to record continuous information on the facility. This information will give you the identity of pest species, an estimate on their population size, the pinpointed areas of pest activity, and any human behavior attributing to the pest problem.

Several monitoring techniques and tools are available to the pest control industry. These include flushing agents, sticky traps, pheromone traps, mechanical traps, light traps, and product inspection. Pest-specific monitoring tools will be included in the appropriate sections of this manual.

Nonchemical options are discussed in several chapters, in keeping with the IPM approach. Use the most appropriate methods for the situation to solve the pest problem and to meet the client expectations.

Pesticide Use

If you incorporate a pesticide into the management plan, select a product that has label directions for the intended use. Match the labeled site, pest, and other considerations to your situation. Important pesticide performance considerations include:

- **Mode of action** (contact, residual, growth regulator)
- Formulation
- Treatment surface (porous or nonporous, staining potential, alkalinity)
- Residual life expectancy
- Recommended equipment
- Visual objectionable residue

Specific Terms for Pesticide Use

Information found on certain pesticide labels is rather specific to the pest management industry. Some terms that appear on labels or product labeling with respect to use in food-handling establishments, commercial accounts, and other structural pest sites include:

- Treatment sites – Many labels will list treatment sites or areas to which the pesticide can be applied. You must be aware of labeled areas and those areas not listed.
- Food-handling establishments – (Figure 1.3) **Food-handling establishments** are areas or places 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 private residence" include restaurants, lunchrooms, caterers, cafeterias, bars and taverns, private clubs, military messes and clubs, food contractors in plants and office buildings, mobile caterers, airlines, ships, drug stores, confectionery stores, dairy product stores, bakery product stores, concession stands, school lunch rooms, colleges and universities, hospitals, homes for aged, orphans and handicapped, federal and state prisons and jails. Private residences are excluded.
- Non-food areas – Included in non-food areas are 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).

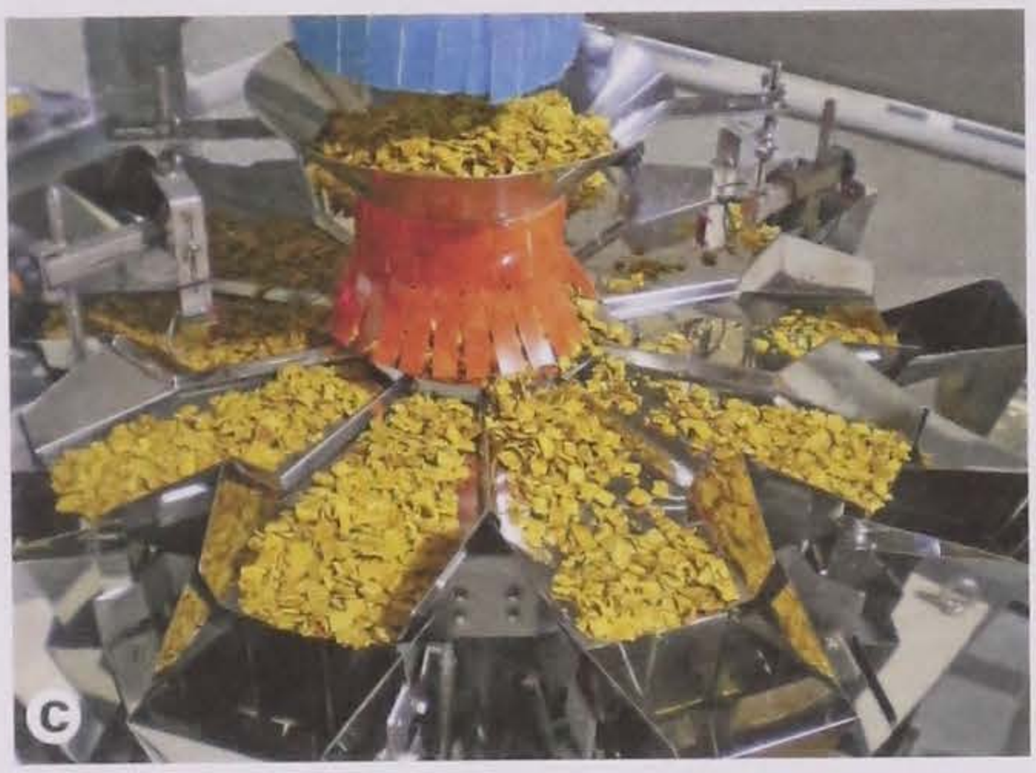


Figure 1.3. Examples of food-handling sites. (A) Bakery; (B) Commercial kitchen; (C) Food packaging site; (D) Food warehouse; (E) Restaurant; (F) Mobile cafeteria. Image credits: (A) www.alpinepastryshoppe.com; (B) www.barryswensonbuilder.com; (C) http://depaulindustries.com/blog/tag/food-processing/; (D) Richard Pipes, www.abqjournal.com; (E) http://post390restaurant.com/; (F) www.barefootstudent.com/

- Food areas – Included in food areas are spaces for receiving, serving, storage, packaging (canning, wrapping, bottling, boxing), preparing (cleaning, slicing, grinding, cooking), edible waste storage and enclosed processing systems (oils, dairies, edible oils, syrups).
- Residual insecticides – Included under **residual insecticides** are products applied to obtain insecticidal effects that last several hours or longer.
  - General – Applications that are general are made to broad expanses of surfaces such as walls, floors, and ceilings or as an outside treatment. This is permitted only in areas using those insecticides so labeled.
  - Spot – A **spot** application is 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" often does not exceed two square feet. A "spot" may be round or long and narrow. In order for spot treatments to be justified, there must be a surface on which insects are likely to occur.
  - Crack and crevice – A **crack and crevice** application means applying small amounts of insecticides into cracks and crevices in which insects hide or through which they may enter a building (Figure 1.4 A). 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, junction or switch boxes. The crack and crevice treatment includes use of sprays, dusts, or baits.
  - Barrier – A **barrier** treatment is an application of a band of insecticides on the lower portion of a building, around the building perimeter and/or near doorways or window (Figure 1.4 B). This treatment is designed to kill insects before they can enter a structure; also known as "perimeter treatment."
  - Structural – A pesticide application is called structural if it is applied on, in, or around a man-made structure.
  - Insect growth regulator (IGR) – Synthetic chemicals that mimic insect hormones are known as **insect growth regulators** (IGR). IGR products tend to have low mammalian toxicity and are less likely to develop resistance in an insect population compared to conventional insecticides.
- Void treatment – A **void treatment** is application of an insecticide into an empty space inside a wall or ceiling, behind a kick plate, inside a table leg, or in any other void that constitutes a prime harborage site for cockroaches, ants, and other pests. The application is usually done through an injector tip.
- Baiting – Placement of insecticide **bait** (a food or other substance used to attract a pest to a pesticide or a trap) into cracks and crevices or voids, or those packaged as bait stations (Figure 1.4 C, D) is one management technique. Wear chemical resistant gloves when placing baits, not only to protect you from the active ingredients, but also to prevent accidental contamination of the bait with unacceptable odors (e.g., cigarette smoke, soap fragrances).
  - Advantages include: the insecticide is enclosed inside a plastic or metal casing; less product used; longer bait life; high effectiveness; precise placement; lowered exposure to humans; and ease of use.

Disadvantages are visibility and the casing may serve as **harborage** for pests if not removed after the bait has been consumed or has deteriorated. Bait stations are typically placed inside cabinets, equipment, and other infested sites.

- Pastes, gels, and other injectable baits may be packaged inside tubes or syringes that you squeeze to apply, or designed to be applied from various types of bait "guns" or with a small spatula or putty knife.

- Space treatment – A **space treatment** is application of a fine aerosol mist of insecticide into any sized, open area with the intent of providing a rapid knockdown and death of the pest, with little or no residual effects. This term covers "fogging," "directed" space treatments, and sometimes "flushing" to chase pests from their hiding places. The mist of insecticide is applied with pressurized aerosols (see page 18).

Pesticide Shelf Life

A pesticide's **shelf life** is the amount of time that a product can be stored and remain effective for pest management activities. Check stored pesticides regularly for signs of deterioration, such as caking/clumping of wettable powders, excessive lumping of granules or dusts, stronger than normal odors coming from an opened container, failure of an emulsifiable concentrate to form an emulsion, or release of a gas when the container is opened. Improper storage conditions accelerate breakdown of the active ingredient(s) and reduce shelf life.

It is recommended that you store pesticides no more than two years. To reduce the amount of pesticides stored, purchase only the amount of pesticide needed for scheduled work. Write the purchase date on the container when it is delivered and use older pesticides first.

Customer Safety

Safe application of pesticides requires a careful, thorough reading and understanding of the pesticide label. Extra care should be taken in storing, measuring, and applying pesticides where children are present. Check the product label to see if people, pets (e.g., birds, cats, dogs), or specific items are to be removed prior to application. This also includes covering aquariums and turning off the filter. You should be specific in instructing customers when they are permitted to re-enter the premises and what precautions to take; written precautions are preferable. At the minimum, people and pets should not return to treated areas until the spray has dried and the area has been ventilated.

Use special care in sensitive areas such as kitchens and food-handling establishments. Food, feed, and food-handling surfaces and equipment must not be contaminated with pesticides. If the areas must be fogged to effect pest management, food-handling equipment and surfaces must be thoroughly washed before food preparation resumes.

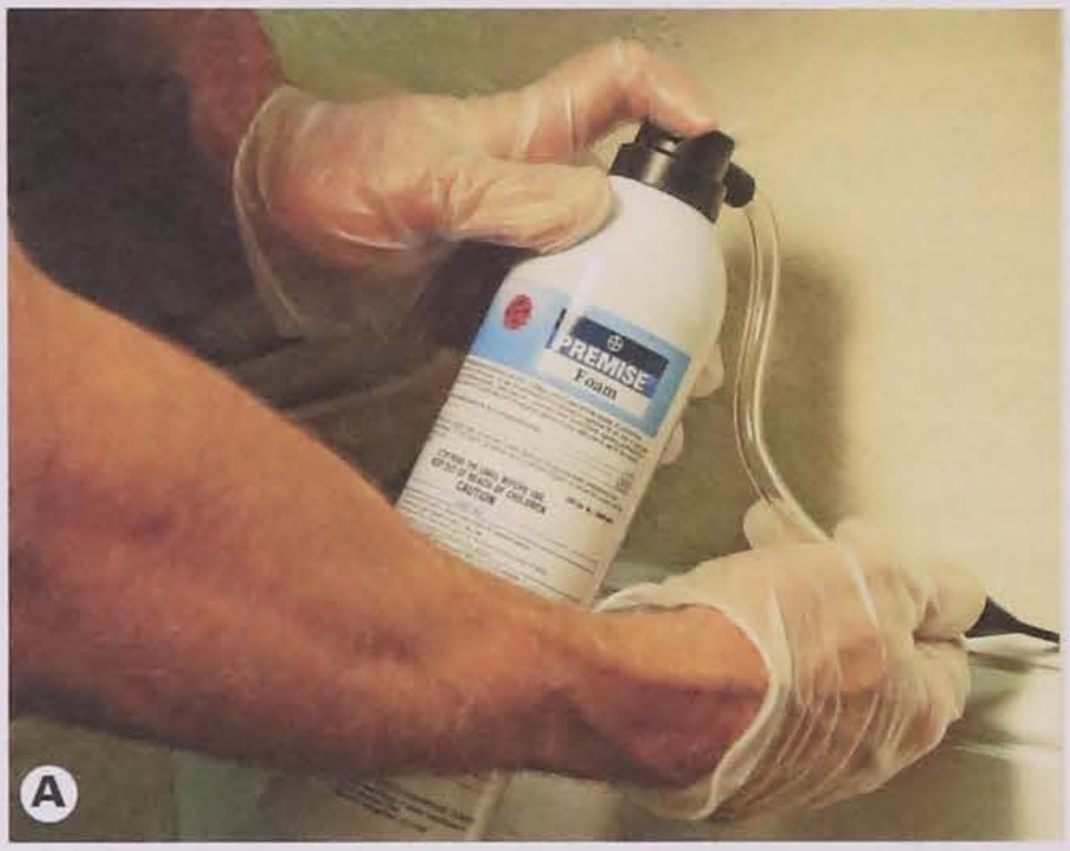


Figure 1.4. (A) Crack and crevice treatment; (B) Barrier treatment; (C) Ant bait container; (D) Gel bait applicator. Image credit: (A) http://hornespestcontrol.com; (B) http://oceanfrontpestcontrol.com; (C) www.mallerysdeals.com; (D) www.pestcontroloutlet.com

Chapter 2
Equipment for the Pest Manager

Learning Objectives

After studying this chapter, you should be able to

- State three types of application equipment that could be used in a perimeter treatment
- Discuss where to use hand-held dusters versus power dusters inside a structure
- Explain the two types of ultra-low volume application devices
- Tell the importance of equipment maintenance in pest management programs

Equipment Types

Several different types of equipment are available to the PMP. Matching the appropriate equipment to the specific situation is an important decision for each application. Carefully follow all directions and precautions provided by the equipment manufacturer.

Compressed Air Sprayers

The hand-held, compressed-air sprayer is used to make residual and **contact insecticide** applications inside or outside a structure. This sprayer consists of a tank (often stainless steel), an air pump, valve, discharge hose, outlet tube, wand, and nozzle (Figure 2.1 A). The nozzle can be adjusted to produce pin-stream, fan, or cone spray patterns.

This sprayer works by using compressed air to deliver the spray. Pushing the pump plunger down forces air through a check valve and compresses it inside the tank. The check valve prevents air from escaping while you pull the plunger back up. Squeezing the trigger on the wand opens a discharge valve that allows the compressed air to force the spray mixture into the hose and out through the nozzle. The more times you push the plunger, the greater the pressure that builds inside the tank.

A pressure regulator and pressure gauge are recommended for compressed-air sprayers. The regulator controls output pressure at the desired setting, allowing you to make a more even application. Some pesticide labels require you to keep the pressure within a desired range throughout the application; in such a case, you will need the regulator and gauge to follow label directions.

Backpack Sprayers

The backpack sprayer is an alternative to the compressed-air sprayer for applying larger quantities of pesticides outdoors either to exterior building surfaces or to surfaces bordering the structure (Figure 2.1 B). Pests such as ticks, fleas, cluster flies, boxelder bugs, and ants may require exterior pesticide applications as a part of the management strategy.

This equipment is held on the shoulders with straps. The unit combines a 2.5 to 5.0 gallon tank, pump, valve, and nozzle into a complete application device. Pressurization of the tank is done by a hand pump action or electric pump. The valve, spray wand, and nozzle are attached to a hose from the pump and operated with one arm.

Large Capacity Sprayers

This equipment consists of a truck-mounted sprayer with common components (tank, pump, filters, gauges, spray gun, and hose on a reel). It is designed for moderate to high volume spraying, such as would be needed for perimeter spraying and termite pre-treatments. The pump is either powered by a separate gasoline engine or via power takeoff from the vehicle. There are various spray guns that could be used with tips to deliver specific patterns of pesticide mixtures. Tank sizes vary from 50 to 300 gallons.

Pressurized Canned Insecticides

Pressurized cans used by PMPs are designed for crack-and-crevice, aerosol, dust, and bait applications (Figure 2.1 C) inside or outside a structure. These canned pesticides contain a pesticide formulation and a gas propellant. The gas pushes the pesticide through the nozzle when the valve is opened. The gas rapidly evaporates, leaving the pesticide floating in the air or on the target surface.

Dusters

Dusters are used to control various types of insects in structural pest management programs. Interior crawling insects such as cockroaches, ants, bed bugs, and silverfish that hide in voids, cracks, and crevices can be controlled with dusts. Outside pests, such as bees and wasps, that create or nest in cavities can also be controlled with this pesticide formulation.

The proper application of a dust results in a thin, barely visible layer deposited inside a crack, crevice, or void. Thick layers of dust should be avoided, as these are repellent to insects.

There are two basic types of dusters:

1. Hand-held dusters – These are the most frequently used by a PMP. They include hand shakers and bulb, bellows, and plunger dusters.
   - Hand shakers – This duster consists of a container that has a screened or perforated lid (Figure 2.1 D). It can be used to apply toxic tracking powders in areas where neatness and exact placement are not concerns. Over application can be minimized by using 16- to 20-mesh screens on the lid. You can attach a long handle to the container to extend the reach of the shaker.

- Bulb and Bellow dusters – These two devices are operated with one hand to squeeze the dust out. Each may hold 4 to 8 ounces of product, so they are ideal for small areas and where neatness is important. A bulb duster is a rubber bulb that has a screw top cap and dust nozzle (Figure 2.1 E). Bellow dusters consist of a short rubberized cylinder with a metal or plastic lid. An extension tube for delivering the dust comes out the bottom.
- Plunger dusters – This device requires use of both hands to operate. Capacity of the duster varies from 14 to 65 oz. of dust. The plunger is forced forward pushing out air, which carries the dust into the area to be treated. Plunger dusters are best used for large areas. A modification of this duster, called the foot pump, is held down with a foot and pumped with both hands; it is used for treating rodent burrows.

2. Power dusters – This equipment is designed for dusting large areas such as attics, crawl spaces, or pipe chases (Figure 2.1 F). They can deliver from 5 to 10 pounds of dust evenly and effectively. Compressed air in a tank forces the dust out of the spout. Electric-powered dusters use a high-volume, battery-powered blower to pick up the dust and carry it into the void.

Ultra-low Volume Applicators

Ultra-low volume (ULV) equipment (also called ultra-low dosage) is designed for treating large areas (e.g., warehouses) with very low amounts of insecticide concentrate. Flying insects and exposed stages of crawling insects are targeted with this type of application; hidden insects (e.g., cockroaches) are often unaffected by the treatment. Specific insecticide products are labeled for ULV applications.

The two types of ULV equipment are:

- Cold foggers – An aerosol is produced when the insecticide hits spinning discs or rotors, causing the liquid to break into small droplets (1-30 microns). Air blasts produced by the machine force the droplets through the nozzle and toward the target area. The higher the air pressure or the smaller the nozzle opening, the smaller the droplets that are produced.
- Thermal foggers – The insecticide concentrate is vaporized with heat (flame or electric). As the heated vapors exit the equipment, they cool and condense into particles ranging from 1 to 10 microns in diameter.

Bait Applicators

Baits are primarily used for ant, cockroach, fly, and rodent control; application can be inside or outside a structure. The delivery method will depend on the pest, bait formulation, and situation. Some bait contains toxicants while others contain IGRs.

Bait Stations or Boxes

Bait stations or bait boxes are devices used in certain insect and rodent management programs. The structure of the device protects pesticide baits from environmental degradation and minimizes nontarget (including human) exposure. An added benefit of stations or boxes is ease of removal of the device (and the pesticide) once pest management efforts are completed at the site.

Traps

Although traps are widely used in monitoring, these devices may also be a method of choice for pest control. Mechanical traps are available to control rodents and other vertebrate animals.

Equipment Maintenance

Equipment must be kept in a well-maintained condition. Check all application equipment frequently and regularly, particularly for leaking hoses and connections, plugged or worn nozzles or tips, and dirty or worn gaskets.

Cleaning of equipment maintains its efficiency and professional appearance. For sprayers, the tank should be kept clean, inside and out. A clean sprayer is unlikely to contaminate a space occupied by humans or food and it does not contain pesticide residues that the applicator could contact. Pest management equipment should be cleaned at least weekly.

D

E

F

Figure 2.1. (A) Compressed air sprayer; (B) Backpack sprayer; (C) Insecticide aerosol; (D) Shaker can duster; (E) Bulb duster; (F) Backpack power duster. Image credit: (A) http://store.doyourownpestcontrol.com; (B) www.naplesbugsolutions.com; (C) www.atthefenceonline.com; (D) www.lowes.com; (E) www.dominionpestcontrol.com; (F) www.lulusoso.com/

Learning Objectives

After studying this chapter, you should be able to

- Define: thigmotactic; ootheca; gregarious
- Explain the health concerns associated with cockroach infestations
- Identify four common, structure-infesting cockroach species
- Identify the cockroach species that can be found accidentally in a structure
- Recognize the signs of a cockroach infestation in a structure
- State the environmental conditions required by cockroaches to survive in a structure
- Explain the relationship between conducive conditions and cockroach population levels
- Describe the nonchemical control tools that can be used against cockroaches
- Categorize where (sites) chemical products are used against cockroaches
- Explain how insecticide repellency will affect cockroach management
- Discuss the primary reasons for bait failure

Chapter 3
Cockroaches

General Biology

Cockroaches are among the most common insect pests found in buildings and homes. They are especially troublesome where food is prepared and sanitation is lacking. They may contaminate food, kitchen utensils, and other items (Figure 3.1), and they leave an unpleasant odor. Because cockroaches move freely between filth and food, they can mechanically transfer microorganisms that cause food poisoning and other illnesses. Many people are allergic to cockroach excrement and shed skins.

Fig 3.1. Cockroaches in electronic equipment. Image by willawake, www.badcaps.net

Cockroaches are flattened, brownish, oval insects. Their head is flexed downward when they are at rest and is concealed by a large shield-like plate called the **pronotum**. They have very long, threadlike **antennae**, large compound eyes, chewing mouthparts, and long, slender running legs (Figure 3.2 A).

Cockroaches undergo gradual metamorphosis (Figure 3.2 B). The female cockroach produces small, bean-shaped egg cases (called **oothecae**) that are deposited (sometimes glued) in out-of-the-way places, but always near a food source. Several nymphs emerge from an egg case. Nymphs resemble adults except they are smaller and lack wings. The nymphs molt several times and gradually become larger, inhabiting the same places as the adults. Cockroaches are prolific breeders, with some species capable of producing several thousand offspring in a year's time.

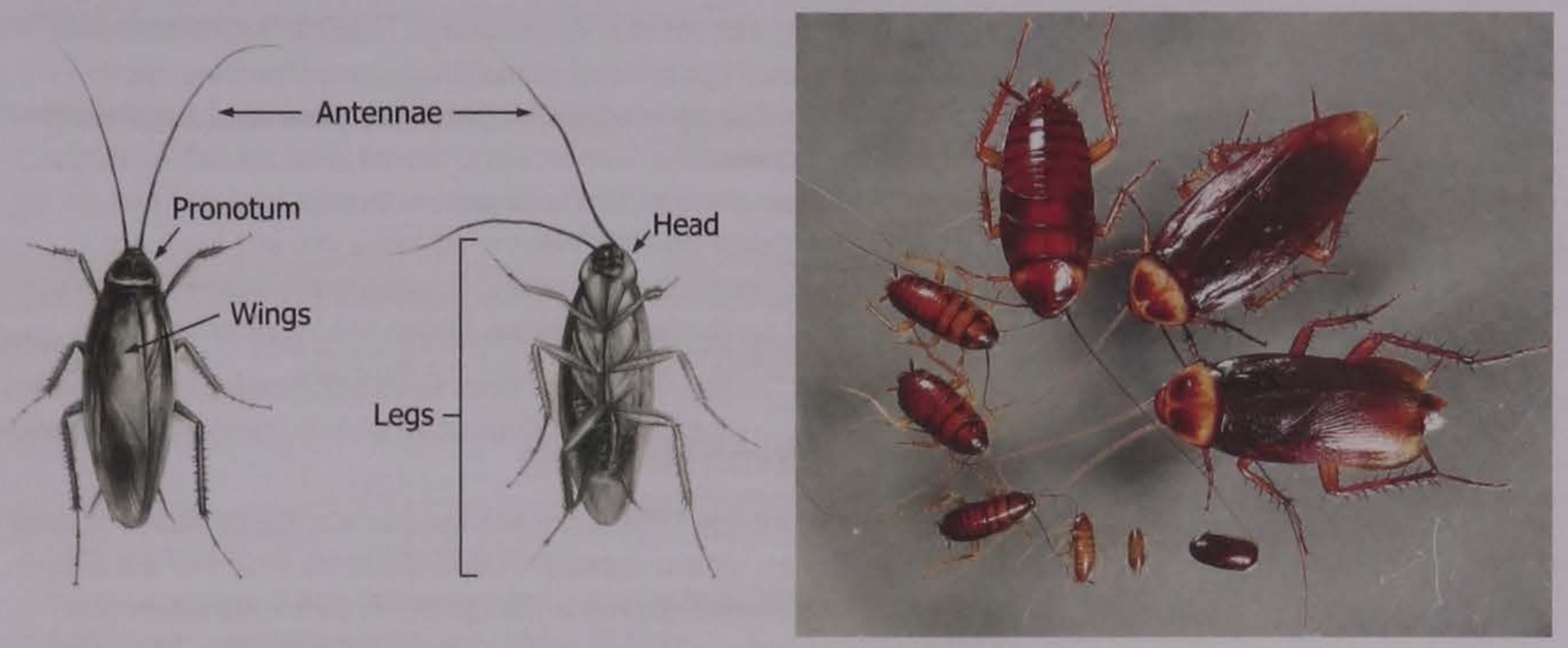


Figure 3.2. (A) Cockroach line drawings, top on left, underside on right. (B) American cockroach life cycle. Image credits: (A) http://kaldrak.files.wordpress.com/2010/08/roaches; (B) www.southwestexterminators.com

Cockroaches are nocturnal (most active at night) and stay in the dark whenever possible. They hide during daylight hours in gaps, crevices, and other tight places where their bodies can touch surfaces both above and below (**thigmotactic response**). At night, they leave their hiding places and search for food. Cockroaches are general feeders and will survive on a variety of foods and will eat anything consumed by people. Their preferred foods have high starch and carbohydrate content. They will also feed on such materials as glue, hair, leather, soap, fabric, bookbinding, wallpaper, dead or living plant material, and filth.

These insects are **gregarious** (preferring to move in or form a group) and large numbers may live in a small space (Figure 3.3). When cockroaches move from their harborage areas, they travel mainly along intersections, "lines," and edges, such as along the back edge of a shelf or the juncture of the wall and floor or ceiling. Cockroaches commonly use plumbing and electrical lines to move from one room to another. This is a special concern in multi-unit dwellings because attempts to control cockroaches in one unit may send them traveling to the next unit.

Figure 3.3. German cockroach gathering. Image credit: www.abcpestcontrol.blogspot.com

Entry into buildings can occur in various ways. They can be introduced in produce boxes, beverage cartons, grocery bags, or on furniture. Some species gain entry through cracks and openings around windows, through sewer lines, or on houseplants or firewood moved in for the winter. While cockroaches thrive where sanitation is poor, even the cleanest home or restaurant can become infested. Ways pests move into and around in a structure, the sanitation level, and available water, food, and harborage are collectively called **conducive conditions**. These conditions promote the buildup of cockroaches (and other pests) in a structure.

Major Cockroach Pests

There are approximately 3,500 cockroach species worldwide and 50 species in the United States. Most of these are tropical insects. Only four are commonly found inside buildings, and a fifth species is an accidental invader. All life stages, including ootheca, can be used for identification. You need to know which species you are dealing with before you can prepare an effective management plan.

German Cockroach (*Blatella germanica*)

The German cockroach (Figure 3.4 A) is by far the most common and important cockroach species from the public health viewpoint.

IDENTIFICATION

- Adults are ½ to ⅝ inch (13 to 16 mm) long.
- They are tan with two dark stripes lengthwise on the pronotum.
- Their wings cover the entire abdomen; insects do not fly.
- Nymphs are smaller and darker in color, with a tan stripe running down middle of back.

LIFE CYCLE

- This species has a high reproductive potential: 4 to 8 oothecae/female; each egg case has 30 to 48 eggs.
- A single mated female can produce an infestation of several thousand new roaches in less than a year.
- Three to four generations per year is common for this species.
- An ootheca is carried by the female until the eggs are ready to hatch (Figure 3.4 B).

HABITS

- An established population is 75% nymphs; approximately ⅓ of a population will forage for food at a given time (Figure 3.4 C).
- They are common in kitchens and bathrooms, remaining close to food and water sources.
- This species has developed resistance to certain insecticides.

PREFERRED HIDING PLACES

- The common places German cockroaches are found include: cracks and crevices under sinks and toilets; beneath refrigerators, ice machines, stoves, and dishwashers; next to trash containers; inside cabinets and pantries; in hollow components of furniture and appliances; and in wall voids.

Brownbanded Cockroach (*Supella longipalpa*)

Although similar in size to the German cockroach, this species is far less common in restaurants and other food-handling facilities, but can be problematic in homes and apartments (Figure 3.4 D).

IDENTIFICATION

- Adults are ½ to ⅝ inches (13 to 16 mm) long.
- They are brown with two lighter bands across the base of the wings and the abdomen; wings commonly are golden in color.
- Males are narrow bodied with wings covering abdomen; females have a broader abdomen and wings shorter than abdomen.
- Males fly quite well and are attracted to lights; females do not fly.
- Nymphs are smaller and light brown in color; light bands run across top of abdomen; a golden oval area is often seen on abdomen (Figure 3.4 E).

LIFE CYCLE

- This species has a moderate reproductive potential: 14 oothecae/female with 13 to 18 eggs/ootheca.
- An ootheca is carried by the female for up to 36 hours before she attaches it to an object (e.g., side or underside of a shelf or piece of furniture) (Figure 3.4 F).
- Eggs hatch in 50 to 75 days; 6 months or longer are required to complete development from egg to adult.

HABITS

- Adults and nymphs do not cluster in the manner of German cockroaches.
- They are commonly found in warm (80° F) harborages above the floor level. Brownbanded cockroaches may infest an entire building; less confined than other cockroaches to areas of food and water. This species can survive at temperatures higher than German cockroaches.

PREFERRED HIDING PLACES

- Brownbanded cockroaches are found: in upper areas of ceilings, walls, cabinets, and closets; behind picture frames and wall decorations; beneath or inside furniture (alternate name is the "furniture roach"); and inside appliance motors, toasters, microwave ovens, television sets, computers, and telephones.

American Cockroach (*Periplaneta americana*)

The American cockroach is the largest and the longest lived of the domestic species in the United States.

IDENTIFICATION

- Adults grow to 1½ inches (38 mm) long.
- Insect color is reddish brown to brown with a pale yellow band around the margins of the pronotum (Figure 3.4 G).
- Wings cover the abdomen; males are territorial and can exhibit gliding flight from a higher to a lower area.
- Nymphs are smaller and reddish brown in color.

LIFE CYCLE

- This species has a lower reproductive potential: 9 to 10 oothecae/female with 14 to 16 eggs/ootheca.
- Female drops an ootheca within a day of being formed (Figure 3.4 H) and may attach the capsule to surfaces with secretions from her mouth.
- Eggs hatch within 55 days; the complete life cycle can take more than 2 years (Figure 3.2 B).

HABITS

- Adults can survive up to 3 months without food, but only 1 month without water.
- They prefer warm (>80° F), damp, and dark areas.
- Clusters of roaches occur in open spaces and in cracks and crevices.
- During warmer months, American cockroaches may be found outside around outbuildings, woodpiles, and mulch piles.

PREFERRED HIDING PLACES

- American cockroaches are found in: floor drains, sump pumps, pipe chases, laundry rooms, boiler rooms, steam heat tunnels, storm and sanitary sewers, grease traps, and basements.

Oriental Cockroach (*Blatta orientalis*)

The Oriental cockroach may be the filthiest of its type based on where it lives and what it feeds on.

IDENTIFICATION

- Adult males are 1 inch (25 mm) long; females are 1¼ inches (32 mm) long.
- Insects are shiny black or very dark brown.
- Females have very small wings (Figure 3.4 I); males have wings that cover ¾ of the abdomen (Figure 3.4 J); these roaches do not fly.
- Nymphs are smaller, lack wings, and are similar in color.

LIFE CYCLE
- This species has a lower reproductive potential: 8 oothecae/female with 16 eggs/ootheca.
- Ootheca is placed in a protected location within a day of completion.
- Eggs hatch within 60 days; the entire life cycle can take up to 2 years.

HABITS
- Nymphs and adults are comparatively slow moving and are generally found on ground level.
- This cockroach species lacks structures on feet, thus cannot climb smooth vertical surfaces.
- It is found in dark, moist locations but often found in a cooler environment than is suitable for American cockroaches.
- They feed on garbage, human waste, and decaying organic matter.
- This species may live outdoors during warmer months beneath leaves and plant mulch, and move from building to building.
- Sticky traps may effectively reduce populations as compared to other cockroach species.

PREFERRED HIDING PLACES
- Oriental cockroaches are found in: sewers, basements, refuge/garbage piles, floor drains, sump pumps, refuse compactors, and crawl spaces.

Pennsylvania Wood Cockroach (*Parcoblatta pennsylvanica*)

Unlike the other cockroach species already mentioned, the wood cockroach is native to Iowa.

IDENTIFICATION
- Adults are ¾ to 1¼ inch (19 to 32 mm) long.
- This species is a chestnut brown color.
- Adults and large nymphs have pale, creamy white or transparent stripe on the outer edge of the pronotum and around ⅓ of the wing edges (Figure 3.4 K).
- Females have short, partially formed wings while males have fully formed wings.

HABITS
- They do not thrive or reproduce indoors.
- They are active day and night and do not congregate in areas, unlike structure-infesting cockroaches.
- Insects may be accidentally brought inside on wood pallets or firewood.

PREFERRED HIDING PLACES
- Wood cockroaches seek the consistently moist environments found in woodpiles, under loose bark, under old wood siding or shingles, and in rotting logs.

Figure 3.4. (A) German cockroach adult; (B) German cockroach egg hatch; (C) German cockroaches, adults and nymphs; (D) Brownbanded cockroach adult; (E) Brownbanded cockroach nymph; (F) Brown banded oothecae. Image credit: (A) Clemson University-USDA Cooperative Extension Slide Series, Bugwood.org; (B) C. Dresz, www.flickriver.com; (C) Daniel R. Suiter, University of Georgia, Bugwood.org; (D) MJ Klesat, www.4.ncsu.edu; (E) Scott Glaze, http://arabpestcontrol.com; (F) www.stewartspestcontrol.com.au


H

Figure 3.4. (G) American cockroaches, adults and nymphs; (H) American cockroach laying an ootheca; (I) Oriental cockroach, female; (J) Oriental cockroach, male; (K) Wood cockroach. Image credit: (G) www.scarboroughvoice.co.uk; (H) Toby Hudson, http://en.wikipedia.org; (I) Arizona Pest Control, www.azpest.com; (J) Phil Myers, http://animaldiversity.ummz.umich.edu; (K) David Larson, http://freepages.misc.rootsweb.ancestry.com

Cockroach Management

The tolerance for cockroaches at any site is essentially zero, so any sign of their presence is unwelcome. If a customer reports seeing a single cockroach, ask where it was sighted. If the roach was far from a potential harborage site or appeared soon after items were brought into the building, there is a good chance the insect was hitchhiking. Advise the person to kill any cockroach seen and search any items for other roaches or oothecae.

There are signs that point to an infestation. For example, you can assume there is an active German cockroach infestation if the customer sees:

- 5 to 10 adults on countertops at night;
- females carrying oothecae;
- many small, dark nymphs; or
- a mixture of adults and various size nymphs.

In addition, an experienced PMP can tell an infested site by the distinctive odor these pests produce.

Inspection

Since cockroaches may be hiding in many places, a thorough inspection is essential to locate as many of these areas as possible (Figure 3.5 A). A great place to start is to do a client interview, which will provide insight into where the insects were seen and what items could be suspect in bringing roaches into the facility.

In addition to inspection tools listed in Chapter 1, some type of flushing agent might be considered for conducting an inspection. The flushing agent irritates cockroaches and forces them into the open, thus revealing hiding places. This agent can be compressed air (such as used to clean computer keyboards) or aerosol pyrethrins. However, the pyrethrins may complicate control efforts by repelling roaches, causing them to move to new, previously uninfested areas. Have a vacuum (with HEPA filter) available to collect roaches that come out in response to the flushing agent.

Look for the following when inspecting a site for cockroaches:

- Live cockroaches
- Dead roaches, including body parts
- Shed skins
- Ootheca
- Dry fecal material (looks like dark grains of sand)
- Fecal spotting in corners (tiny dark spots)

When inspecting, don't overlook the possibility of there being more than one cockroach species present, especially in large buildings such as schools, hospitals, shopping centers, and multifamily dwellings. These sites provide the different environments that different species prefer.

Cockroach inspections must be performed in an organized, methodical manner because there are countless cracks and crevices in a structure in which roaches can hide. A systematic way to inspect a facility or home is to begin at a door and inspect one "zone" (3 to 5 feet; 1 to 1.5 m) extending from floor to ceiling at a time. Continue this procedure around the perimeter of each room, inspecting each piece of equipment or furniture encountered. Before leaving a room, inspect any items in the center.

Keep records of each inspection. Problem areas should be noted on the service record and building floor plan as a way to follow pest population levels over time and for clearer communication with clients.

Sanitation

Good sanitation is extremely important for effective, long-term management of cockroaches. It is best to involve the customer whenever possible. Removing available food and water stresses roaches and makes them forage over greater distances, which increases the chances they will be detected.

Crumbs, grease, spills, and other food debris should be cleaned from floors, walls, furniture, and equipment. Wash all soiled dishes and kitchen utensils after use. Discard uneaten pet food after the animal has fed. Loose food should be stored in tight-fitting containers, and garbage, cardboard boxes, and paper bags should not be allowed to accumulate. Items in food storage areas should be removed from cardboard boxes and stored off the floor on stainless steel racks. Moisture leaks should be repaired and floor drains routinely sanitized.

Practical habitat alterations also are very important to cockroach management. This includes: repairing defects such as loose baseboards and moldings; using copper wool and sealants around pipes and other wall penetrations to prevent access to wall voids; sealing cracks and crevices near food and water sources; and sealing around door frames, electrical outlets, and openings to hollow doors and table or equipment legs.

Remember that a cockroach infestation does not necessarily indicate poor sanitation or building upkeep. Once a population becomes established in a facility, sanitation and exclusion techniques will not eradicate it. Cockroaches are very adaptable and will find food and harborage, though the population size will be smaller.

Nonchemical Control Tools

There are a few nonchemical options for cockroach pest management. A temperature of 120° F will kill roaches if exposed for several hours, while cockroaches held at 0° F will die in an hour if the temperature drop is sudden. This approach can be useful for dealing with roaches that may have been brought into a site in boxes, sacks, or other small items.

A vacuum can be used to remove roaches once their harborage is detected (Figure 3.5 B). Combining vacuuming with a flushing agent may let you remove more individuals. Make sure the vacuum is equipped with a HEPA filter so that allergens (e.g., shed skins and feces) are trapped rather than allowed to become airborne.

Although not a complete control tool, vacuuming is very useful because it:

- immediately reduces the population and so may also reduce the total amount of other control measures;
- provides an alternate method of removing pesticide-resistant individuals;
- can be used without removing people from the work area;
- reduces the number of cockroaches (live or dead) that the customer encounters; and
- removes harmful allergens.

Traps are also an important part of cockroach pest management (Figure 3.5 C, D). These should be considered as monitoring tools, to indicate species present, general locations in a structure, and population size and makeup (e.g., nymphs and adults versus only adults).

Sticky traps and glue boards should be placed at strategic locations, such as beneath sinks or behind refrigerators, and positioned flush against walls, corners, or at the junction of two or more construction elements.

Monitoring traps can be purchased with or without baits or lures. It is important to remember that these baits/lures are only attractive for 3 inches or less. Maximum activity occurs when cockroaches are presented with new environmental situations. Therefore, if an environment never changes (e.g., stored items left in one place for a long period of time), the cockroaches will explore less and spend as much as 90 percent of their time resting in harborages.

Chemical Control Tools

Wide varieties of insecticide active ingredients and formulations are available for cockroach control. Insecticide applications should be coordinated with other pest management procedures. Insecticides placed directly into or near cockroach harborages will produce the best results. You will need to select insecticide formulations and products that are labeled for crack-and-crevice, spot, general, and structural applications. Always read the label to be sure that the approved uses are completely consistent with the application.

Structures may have steamy areas, wet floors, or areas that are regularly washed down. Very little residual insecticide action should be expected in these locations; consider using non-residual products here. Voids that remain dry, however, may be most effectively treated with dusts or residual aerosols with crack-and-crevice tips. Bait applications need to be placed near harborages and in areas where cockroaches are expected to forage. Greasy surfaces decrease the effectiveness of insecticide applications.

Figure 3.5. (A) Kitchen inspection; (B) Use of vacuum to remove cockroaches; (C) Sticky trap placement example; (D) Sticky trap catch; (E) Cockroach bait placement; (F) Cockroach feeding on bait. Image credit: (A) http://www.ntxpestcontrol.com; (B) http://www.critter-company.com/insects/cockroaches; (C) Mark H. Shour, Iowa State University Extension and Outreach; (D) Erin Bauer, University of Nebraska-Lincoln; (E) Pestec, http://www.birc.org/EcowiseB3.htm; (F) www.qpm.ca

REPELLENCY

Research has demonstrated that many insecticides repel cockroaches. This behavioral characteristic is strongly exhibited by German, American, Oriental, and brownbanded cockroaches. Because repellency causes avoidance by cockroaches, the entire building may need to be treated at the same time. Cockroaches repelled from an infested area may seek harborage in previously uninfested areas, thus monitoring throughout the entire structure is essential. Recent studies have shown that many insecticide dusts are repellent. Even food grade flour and sugar repelled cockroaches. Boric acid was the least repellent powder tested. Most commonly used liquid insecticides also repel roaches, while microencapsulated formulations are less repellent. Hydramethylnon is practically non-repellent.

RESIDUAL TREATMENTS

Crack-and-crevice treatment is a standard approach for all species because cockroaches like to hide in small spaces. This type of application has the advantages of using little product, placing the pesticide where it is needed, and minimizing the exposure to people. Common **active ingredients** applied via crack and crevice include acephate, bifenthrin, chlorfenapyr, cyfluthrin, cypermethrin, imidacloprid, lambda cyhalothrin, permethrin, prallethrin, and pyrethrins.

Dusts are preferred for treating wall voids. You need very little dust to effectively coat the interior surfaces of the void (heavy dusting is wasteful and repellent). Dusts have the advantages of residual action and being safer to use around electrical lines/outlets. Common dust active ingredients include boric acid, deltamethrin, orthoboric acid, pyrethrins, and silica.

Residual insecticides are also labeled for spot treatments where roaches are likely to forage, as well as for barrier treatments, to prevent cockroaches from entering an area or building.

INSECT GROWTH REGULATORS

IGRs can complement conventional insecticides in cockroach management programs. Properly timed applications will cause abnormal development (deformed wings and/or sterile adults) and provide effective control. Hydroprene is the most common IGR active ingredient.

NON-RESIDUAL TREATMENTS

Non-residual insecticides are those products applied to obtain control of roaches only during the time of application. These products are often applied with aerosol or ultralow volume equipment and are directed into areas of suspected cockroach harborage. Indiscriminant dispersal of non-residual insecticides into the air (e.g., fogging or space treatment) in kitchens, dining rooms, storage areas, etc., should normally be avoided because it will only drive cockroaches deeper into wall voids or other protected locations. Common active ingredients of non-residual insecticides include hydroprene, prallethrin, and pyrethrins with piperonyl butoxide.

BAITS

Cockroach baits have revolutionized the pest control industry (Figure 3.5 E, F). These products have incorporated small amounts of slow-acting insecticides in an attractive food substrate. Common active ingredients include abamectin, disodium octaborate tetrahydrate, fipronil, hydramethylnon, imidacloprid, indoxacarb, and orthoboric acid. Pastes and powders are applied in small dabs or spots close to harborage sites, while gels should be injected directly into the cracks and crevices where roaches hide. Plastic bait stations are also placed near cockroach activity, preferably near edges and corners. Smaller droplets of baits are more effective than large droplets in an area. However, you must set out baits in many prime locations when large populations are found.

Store baits away from other pesticides so that the baits do not pick up odors that will reduce their attractiveness to cockroaches. Likewise, it is best to use baits alone in a small area, so that a conventional insecticide does not interfere with the bait's effectiveness.

BAIT FAILURES

As effective as baits are, you may still encounter situations in which they do not provide the control you would expect. The most common reasons for bait failures are poor sanitation, inadequate bait placement, immigration into the site, and bait aversion. Good sanitation ensures that roaches are drawn to baits rather than other food sources. Improper bait placement is often a result of inadequate inspection and/or time taken to place enough baits. Don't overlook the possibility that new roaches are being brought into the account, overwhelming the amount of bait previously placed.

Another cause of bait failures with German cockroaches is bait aversion, also called behavioral resistance. When this occurs, roaches actually move away from baits, especially when formulated as a gel. Cockroaches that avoid bait will survive and pass on that tendency to their offspring. You should suspect a problem with bait aversion if all of the following apply in the management site:

- A cockroach infestation has been continuous and longstanding despite the baiting;
- Roaches are not being introduced from outside the account;
- Sanitation is satisfactory;
- Bait was properly placed (e.g., correct location, amount, and number of placements);
- Baits have not been contaminated with cleaners or pesticides; and
- Roaches are living in baited harborages.

Learning Objectives

After studying this chapter, you should be able to

- Define: swarm, caste, budding, trophallaxis, petiole, gaster, trail pheromones
- Describe the social order within ant colonies
- State the key body characteristics used to identify ant species
- State the distinguishing features between swarming ants and termites
- Name six ant species found in or near structures
- Associate the specific odor produced by crushing an ant body for two common ant species
- List five common locations where ants build their nests
- Discuss the seasonal food preferences of three ant species
- Explain the human health concerns associated with pharaoh ants
- List the four approaches for managing ant infestations
- Discuss how baiting controls ant colonies
- Name three ant bait formulations
- Discuss choice of insecticide and application site for ant management

Chapter 4
Ants

General Biology

Ants are among the most common pests in and around buildings. They may build nests in the soil, under concrete slabs, stones, or boards, adjacent to foundation walls, in the walls of a structure, or in decaying wood. The activities of most ants are more annoying than harmful, especially when they enter buildings in search of food. On occasion, ants will contaminate food and can mechanically transfer disease-causing organisms, but they are generally not considered a public health pest.

Ants undergo complete metamorphosis (Figure 4.1). Larvae are white, legless, and grub-like. Most clients only encounter adult ants, as the "brood" (eggs, larvae, and pupae) are protected and tended in the ant colony.

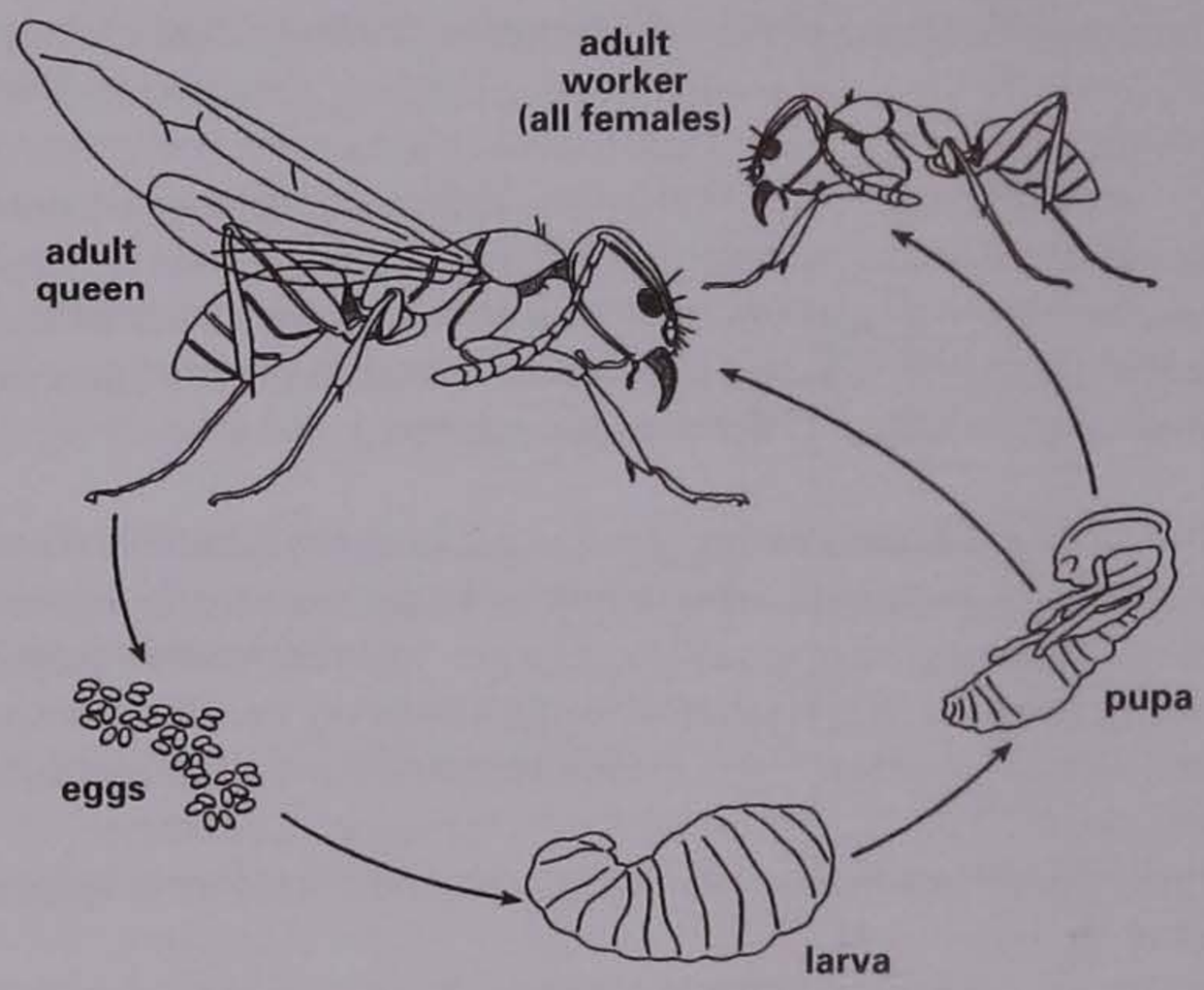


Figure 4.1. Ant life cycle stages. Image by University of California IPM Pest Notes #12

The Ant Colony

Ants are social insects and live in colonies of hundreds or many thousands of individuals. There are three distinct adult **castes** in their social order: queens, workers, and males.

- Queen ants are responsible for laying eggs. Some ant species maintain more than one active queen in the colony.
- Worker ants are wingless, sterile, female ants that comprise most of the members of the colony. This caste is responsible for: foraging for food; tending the queen; caring for eggs, larvae, and pupae; building and repairing the nest; and protecting the colony. It is common that different individual ants specialize in a particular task.
- Male ants are only produced prior to reproductive activity in the colony. They have fully formed wings. Along with winged, reproductive females, these individuals leave the nest, **swarm** in a "nuptial flight," and mate. Winged reproductive ants are called swarmers.

Swarms can involve thousands of individuals leaving the nest within an hour's time. The winged swarmers are often confused with swarming termites, but they can be distinguished by differences in wings, antennae, and **petiole** (the "waist" between the **thorax** and the large part of the abdomen—called the **gaster**). Ants have elbowed antennae, a narrow petiole, and unequal wing length (front wings longer than hind wings). Termites have thread-like antennae, a broad waist, and wings of equal length. See Figure 4.2 for comparisons.

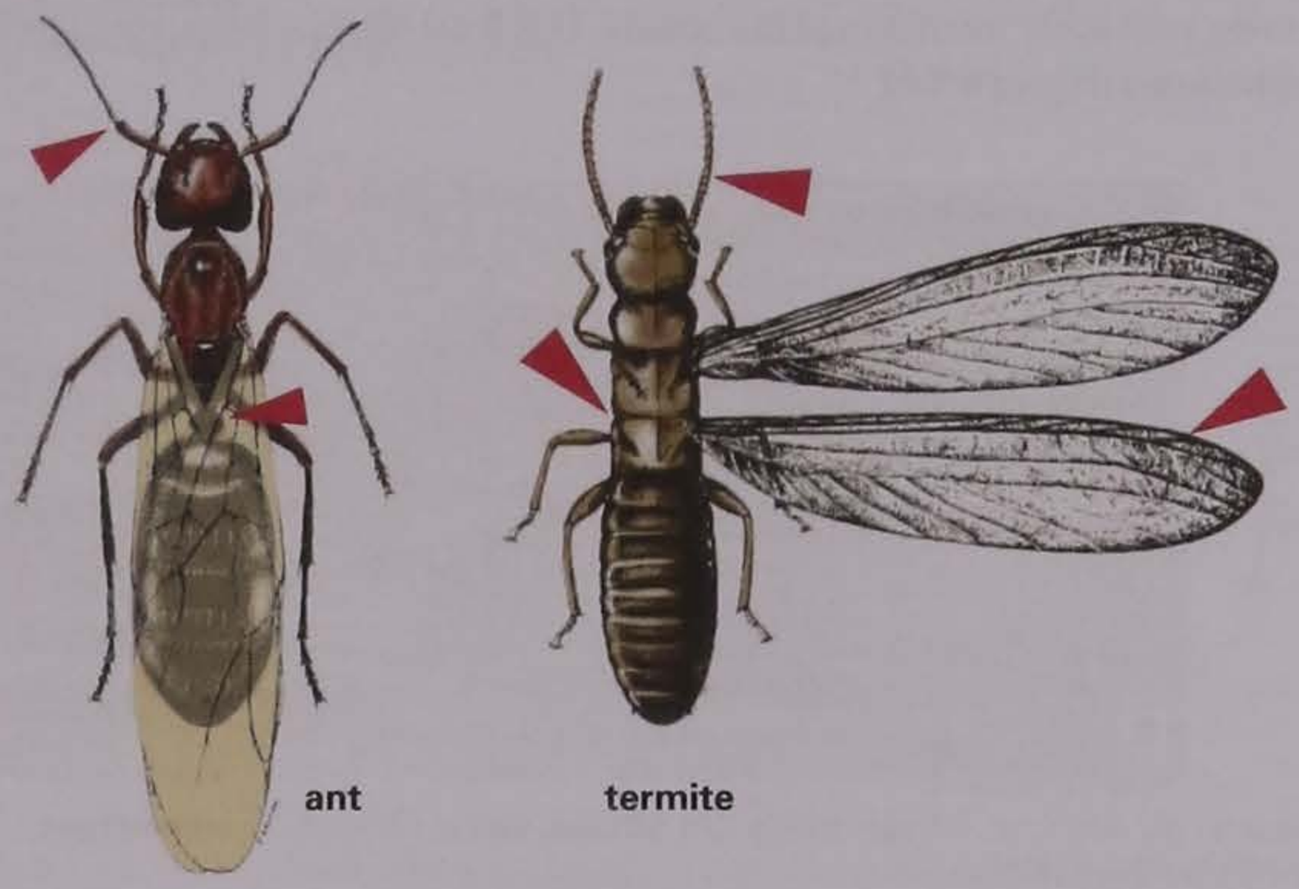


Figure 4.2. Ant – termite comparison. Red arrows indicate that antennae, wing length, and petiole are characteristics to quickly distinguish these two pests. Image by Michael Merchant, Texas A&M University

Starting a New Colony

After the winged reproductive ants finish mating, the males die. Each winged female will search for a suitable nest site, tear off (or perhaps eat off) her wings, and begin a new colony. The female will lay eggs and tend the young, feeding them with secretions from her mouth. Once the young develop into workers, they will assume colony responsibilities and the queen will continue egg laying. Approximately 90 percent of new queens fail.

Ant species with multiple queens can start new colonies by **budding**. A queen mates within the nest (without swarming) and, with workers and some brood, leaves the parent colony to start a new colony at another location. This type of colony formation is more successful because it already contains workers.

Colonies can live for several years and move from place to place. If a nest site becomes too small, dry, or otherwise unsatisfactory, the workers move the queen and brood to a new site. This type of behavior and budding can be a response to pest management control efforts, so it is important to realize how quickly an ant colony can invade a new nest site.

Foraging and Feeding

Ants eat a wide variety of foods. Common foods include other insects, seeds, nectar, greases, sugars, and honeydew (excretion of plant sap-feeding insects such as aphids and scales). Even within a species, preferences will change over the course of the year and may depend largely on what foods are available. Food is gathered by foraging workers and carried to the nest for sharing with other members of the colony. This food-sharing behavior is called **trophallaxis** (Figure 4.3 A).

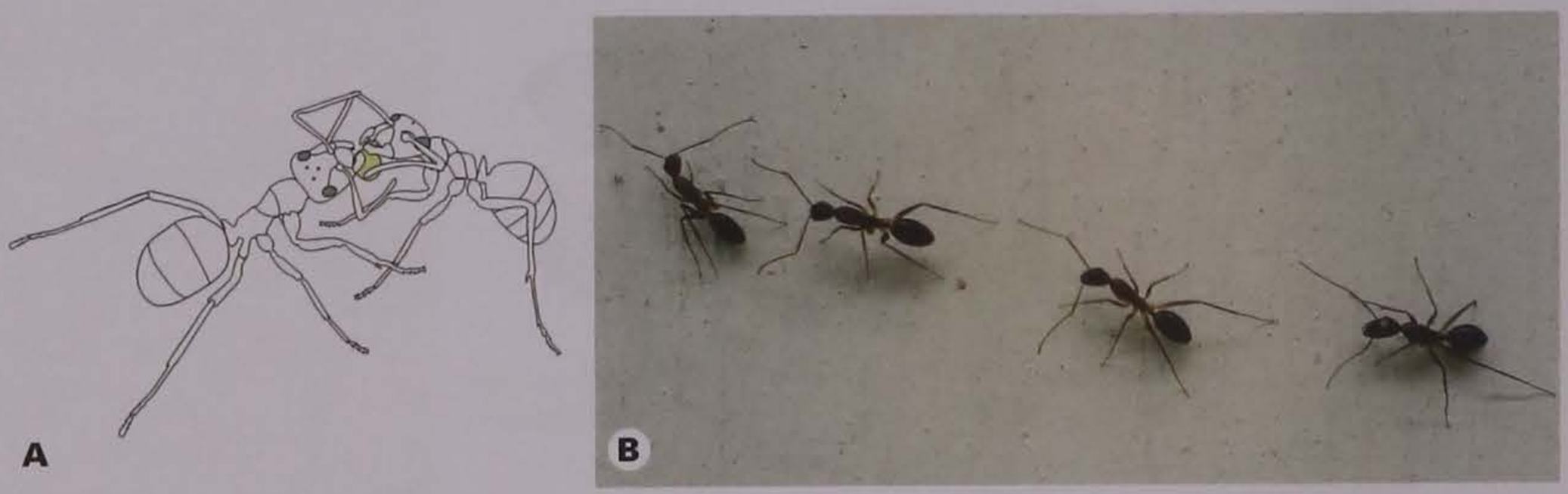


Figure 4.3. (A) Food-sharing, trophallaxis; (B) Ant trail. Image credit: (A) Mitsua, www.flickriver.com/photos/msitua; (B) D. Vorieh, www.yourmoney-yourplanet.com

At any given time, only a small percentage of workers will leave a colony to forage. It is this behavior that most frequently brings ants inside a structure. The foraging workers will leave chemical trails (called **trail pheromones**) when they find food so that other foragers can find the food source and bring it back to the colony. This explains why a client will see lines of ants coming and going from a food source, such as unrinsed dinner dishes in the kitchen sink (Figure 4.3 B).

Major Ant Pests

Each ant species will have its own peculiar traits. Knowing where ants prefer to nest, how they forage, what they eat, and when and how they set up new colonies is essential to every step of the pest management process, from initial inspection through implementation of a management plan.

Collect some ants at the job site for identification. If necessary, set out honey or peanut butter on an index card and wait for ants to arrive. Check the card within the hour. Once ants arrive to the bait, pick up the card with ants on it, place in a ziplip plastic bag, and hold in a freezer. Later, look at the ants under the microscope and preserve some in alcohol as a record. Ant identification is based on workers and involves looking for such traits such as (Figure 4.4):

- shape of thorax
- number of nodes making up the petiole
- spines on the thorax
- antennal segments and clubs
- color and size
- distinctive odors when crushed

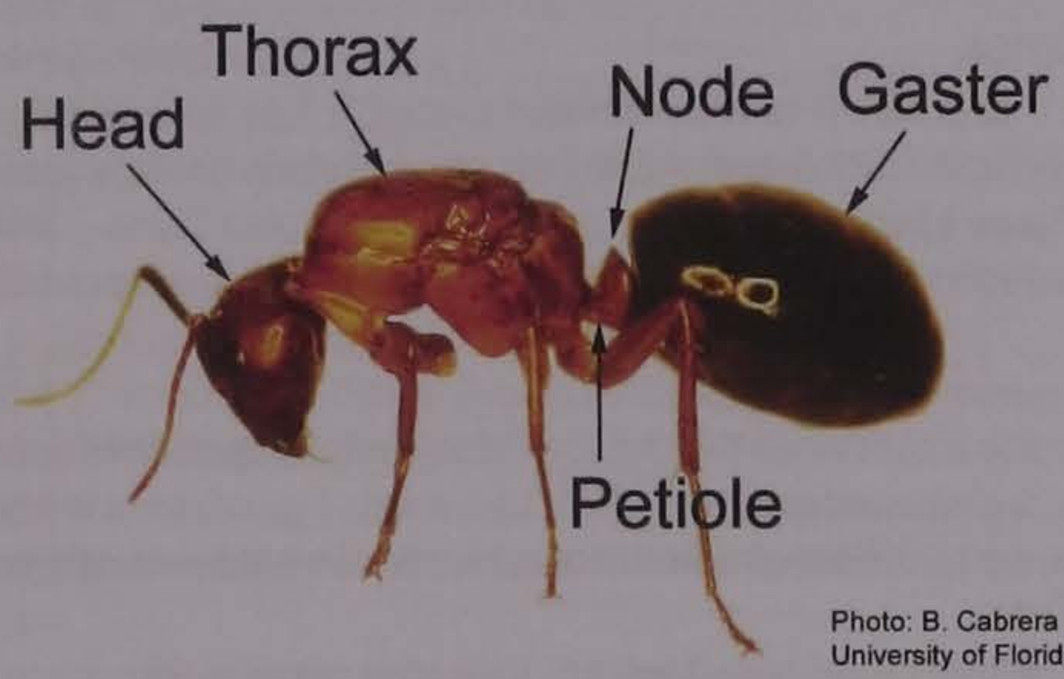


Figure 4.4. General ant anatomy. Image credit: B. Cabrera, University of Florida

Acrobat Ant (*Crematogaster species*)

These ants get their name from the habit of holding their abdomens over their bodies when alarmed.

IDENTIFICATION

- Ants are ⅛ to ¼ inch (3 to 6 mm) long.
- Color varies from yellowish brown to reddish to black; abdomen is usually darker (Figure 4.5 A).
- Ants have a two-node petiole that attaches to top of abdomen; abdomen is heart shaped when viewed from above; thorax is uneven with 2 spines.

HABITS

- They generally nest outdoors under stones, in stumps or dead wood, behind house veneers, and in landscape timbers.
- They are commonly found in wood already damaged by carpenter ants or termites.
- Nest locations often are associated with moisture problems and water leaks, such as damp roofing wood or insulation board.
- These ants can cause damage to wood in which cavities are excavated.

FOOD PREFERENCES

- Acrobat ants feed on sweets, meat, and grease.
- Foraging activities most commonly bring these ants inside a structure.

Carpenter Ant (*Camponotus pennsylvanicus*)

These large ants are named for their nest sites and the manner in which they build them.

IDENTIFICATION

- Ants are ¼ to ½ inch (6 to 12 mm) long.
- Their coloring is black (Figure 4.5 B) with some workers partially reddish brown (Figure 4.5 C).
- This ant species has an evenly rounded thorax and a one-node petiole.

HABITS

- They become a pest when they forage indoors, produce swarms in or near buildings, and nest indoors.
- This ant species builds nests in structural wood of plants or buildings, or similar matter.
  - The moisture content must be high, indicative of water damage.
  - Nests are often built in wood softened by decaying fungi.
  - Ant respiration and defecation adds to humidity in nest.
  - Ants do not eat the wood.
  - Damage further weakens water/fungi-damaged wood.
  - Common sites for nests include tree stumps, tree holes, hollow areas in tree trunks, firewood, rotting fence posts, structural timbers (roof rafters, window frames, door frames, kitchen cabinets), and rigid foam insulation.

- Nests last for a long time; colony can move nest if site is disturbed.
- The main colony is formed by new queen (Figure 4.5 D); **satellite colonies** (contain large numbers of foraging workers but lack a queen or developing young) are also formed if more space is needed. Satellite colonies maintain interaction with the main colony. It is thought that most nests found in structures are actually satellite colonies.
- Workers may wander up to 300 feet (91 m) from the nest in search of food. They often follow manmade guides (e.g., driveways, wall edges) in their search. PMPs commonly find carpenter ants traveling across telephone wires to get to a house.

FOOD PREFERENCES

- Carpenter ants eat a wide range of foods including dead insects, plant and fruit juices, honeydew and other sugars, eggs, meats, cheese, cakes, and food grease.
- Proteins are preferred in spring and late summer for brood development; carbohydrates are sought during fall.

Items to look for when inspecting a site:

- Wooded areas near a structure; stumps, rotting wood, overhanging branches
- Landscape timbers and wooden decks (pressure-treated wood does not deter these ants since they do not eat the wood)
- Clogged gutters
- Moss or mold on roof shingles
- Water damaged windowsills, doorjambs, and sill plates
- Wood in contact with soil
- Bay and box windows
- Improper or nonexistent roof flashing
- Hollow porch columns
- Firewood stacked against side of building
- Wood with greater than 20 percent moisture (moisture meter needed)—under sink, near dishwasher, around tub/shower stall, attic beneath a roof leak
- Coarse sawdust piles containing insect body parts
- Wood that has smooth, clean tunnels throughout not necessarily following annual growth rings (Figure 4.5 E)
- Sounds of ant activity—sometimes a nest can be located by careful listening (unaided ear or stethoscope) for sounds like crinkling cellophane or paper
- Hollow sounds—gently tapping on structural wood with the handle of a screwdriver may yield a hollow sound and should be pursued as a possible nest site
- Ants seen indoors during summer and fall months only indicate an outdoor nest, while ants seen indoors year round or winged ants seen indoors before swarming may indicate an indoor nest

Crazy Ant (*Paratrechina longicornis*)

Workers of this species tend to run aimlessly about, accounting for its common name.

IDENTIFICATION

- Ants are ⅛ inch (3 mm) long.
- Workers are brown to black, with a greyish sheen.
- Ants have a one-node petiole; very long legs and antennae compared to its size; and antenna with 12 segments without a club; the first antennal segment is much longer than other antennal segments combined (Figure 4.5 F).

HABITS

- They become pests when they nest inside a structure.
- Nest location varies:
  - prefers to nest outside in crevices, bark mulch, leaf litter, rotten plants, and under above-ground swimming pools;
  - uses small crevices inside buildings; and
  - often nests near hot water pipes or between floors.
- They exhibit nomadic colony behavior, tending to change nest areas frequently.
- New colonies are produced by budding.
- Despite its wild running behavior, foragers generally follow established foraging trails, usually along an edge (foundation or wall).

FOOD PREFERENCES

- Crazy ants feed on animal material, other insects, sweets, and kitchen scraps.

Larger Yellow Ant (*Acanthomyops interjectus*)

This common ground nesting ant has a characteristic citronella or lemon odor when crushed.

IDENTIFICATION

- Ants are 3/16 to 5/16 inch (5 to 8 mm) long (Figure 4.6 A).
- Workers are yellow to reddish yellow; swarmers are darker red.
- Ants have a one-node petiole; an antenna with 12 segments with an antennal club that gradually enlarges to the tip.

HABITS

- Nests are commonly formed outside under stones or logs, along building foundations, and under heated concrete slabs. This species is also called "foundation ant."
- These ants become pests when swarmers emerge in a house (Figure 4.6 B). They generally resemble winged termites.
- Larger yellow ants do not damage structure or carry disease; swarming typically lasts a few days.

Figure 4.5. (A) Acrobat ant cluster; (B) Carpenter ant worker, black; (C) Carpenter ant worker, red and black; (D) Carpenter ant queen and eggs; (E) Carpenter ant damage; (F) Crazy ant. Image credit: (A) Ray Pistrum, http://redsgoodvsevilcowbarn.blogspot.com; (B) Dave McMullan, www.quality1stpestsolutions.com; (C) Mr. X, Wikipedia, Creative Commons; (D) Alison Bockoven, www.6legs2many.wordpress.com; (E) www.andrewhazelden.com; (F) April Nobile, www.azoresbioportal.angra.uac.pt

FOOD PREFERENCES
Larger yellow ants feed almost exclusively on honeydew gathered from aphids and mealybugs feeding on the roots of shrubs.

Little Black Ant (*Monomorium minimum*)

This species, although related to Pharaoh ants (see page 46), differs in color and nest locations.

IDENTIFICATION
- Ants are 1/16 inch (1.5 mm) long.
- Workers are shiny, jet black (Figure 4.6 C).
- Ants have a two-node petiole; antenna with 12 segments and 3-segmented club; and an abdomen tipped with a small, weak stinger.

HABITS
- Ants become pests when they nest inside a structure (nests formed in woodwork, in masonry features, or against foundations).
- Outdoor nest locations are in open areas free of vegetation.
  - Nests can be detected by a very small crater of soil.
  - Nests are made inside rotted wood, under tree bark, in old termite galleries, beneath rocks, and in lawns.
- This species creates very large colonies with multiple queens.

FOOD PREFERENCES
- The little black ant feeds on plant secretions and aphid honeydew.
- It will also feed on sweets, meat, bread, grease, vegetables, and fruit.

Odorous House Ant (*Tapinoma sessile*)

Their characteristic rotten-coconut odor—when crushed—and their regular colony movement help distinguish this ant species from other pest ants.

IDENTIFICATION
- Ants are 1/16 to 1/8 inch (1.5 to 3 mm) long.
- Workers are brown to black in color (Figure 4.6 D).
- Ants have a one-node petiole hidden by abdomen; antenna with 12 segments but no club.
- Foragers run erratically when disturbed, holding their abdomen up in the air.

HABITS
- Ants become pests when foraging and/or building nests inside a structure.
- This species requires moisture for nest sites.
  - Inside nests usually are formed near hot water pipes or near other warm sites (e.g., window sills), beneath a floor, in an old termite gallery, or in the floor under toilets
  - Although nests outside can be almost anywhere, common sites include under stones, boards, or patios; in loose bark or tree cavities; in animal nests and beehives; in cracks of foundations; or under siding.

- Colonies may contain multiple queens and from 100 to 10,000 workers. Queens and workers may live several years, but males die soon after mating. New colonies are formed by mating of queens and males outside the nest and also by budding.
- This species moves the nest site as often as once a month. Colonies may be moved indoors during cool/cold weather. It is common that a division of a colony occurs when the nest site is moved. A given structure may harbor several nests at one time.
- Foragers work day and night along well-established trails; foraging occurs year round. Trails may be found along guidelines such as foundations, baseboards, counters, carpet edges, vines, and sidewalks.

FOOD PREFERENCES

- Odorous house ants feed primarily on sweets and honeydew from aphids and scale insects (Figure 4.6 E). They will also feed on nectars, live and dead insects, and carcasses of birds and small mammals. Indoors they feed on most household foods, especially sweets.
- These ants are likely to invade houses during rainy weather because their supply of honeydew has been washed away.

Pavement Ant (*Tetramorium caesptium*)

Associated with hard surfaces, this ant has distinctive markings on its head.

IDENTIFICATION

- Ants are 1/16 to 1/8 inch (1.5 to 3 mm) long.
- Workers are reddish brown to black; legs and antennae are a lighter color than body (Figure 4.6 F).
- Ants have a two-node petiole; thorax with a pair of spines; sculptured, parallel furrows that run the length of the head and thorax (Figure 4.6 G).

HABITS

- This species gets its name from nesting under pavement and sidewalks. They produce the soil mounds seen in hard surface expansion joints and cracks. These ants will also nest around foundations, under decorative stones, and any other item that will give them shelter.
- Indoor nest locations can be found on the ground floor, in walls, insulation, and under floors. They prefer sites near heat.
- A colony can have multiple queens and up to 30,000 workers in a single nest.
- Workers forage at night along building edges and wall-floor junctures. They will travel pipe channels from one part of a building to another.

FOOD PREFERENCES

- Pavement ants feed on meat, bread, cheese, nuts, sweets, grease, dead insects, and animal carcasses.
- Workers will also tend aphids and mealybugs.
- These ants will collect and store seeds at nest site.

Pharaoh Ant (*Monomorium pharaonis*)

This tiny ant gained its name from the mistaken belief that it was one of the plagues of Egypt during the time of the Pharaohs. Today, this ant is a serious pest of structures, especially hospitals.

IDENTIFICATION

- Ants are 1/16 inch (1.5 mm) long; queens may be 1/8 inch (3 mm) long.
- Ants are pale yellow to pale red; end of abdomen is darker (Figure 4.6 H).
- Ants have a two-node petiole; 12-segmented antennae with 3-segmented club; and larger eye.

HABITS

- Ants become a pest when they:
  - Feed on open wounds, mouths of sleeping infants, or enter intravenous feeding bottles attached to patients;
  - Mechanically transfer *Salmonella*, *Streptococcus*, *Staphylococcus*, and *Clostridium* bacteria; and
  - Cause shorts in electrical equipment when they set up nests there.
- This species cannot overwinter outdoors in the upper Midwest.
- Ants build nests inside a structure close to food sources:
  - Voids in walls, window frames, door frames; behind loose boards; between floors; between insulation paper and wall or ceiling surface; in electrical fixtures; and in furniture.

COLONY SIZE AND STRUCTURE

- Colonies have multiple queens.
- Colonies are very large with hundreds of thousands of individuals.
- Queens mate with males inside nest.
- Colonies bud when disturbed. One or more queens, workers, and some brood move to a new location.
- Locating where foraging ants disappear into voids gives the best clues as to colony location (Figure 4.6 I).

FOOD PREFERENCES

- Pharaoh ants eat a wide range of items: syrups, fruits, meats, breads, and dead insects.
- This species will even feed on soap and toothpaste.

Thief Ant (*Solenopsis molesta*)

The thief ant is a tiny species with an infamous lifestyle.

IDENTIFICATION

- Ants are 1/32 to 1/16 inch (0.75 to 1.5 mm) long.
- Body color is yellow to dirty-brown (Figure 4.6 J, K).
- Ants have a two-node petiole; antenna with ten segments and a two-segmented club; a stinger present on tip of abdomen and has a small eye.
- This species is often misidentified as Pharaoh ants.

HABITS

- Ant name is derived from its lifestyle: this species builds their nest near or inside the nest of other ants. It steals the larvae and food of the victim colony.
- Colony size is small and contains many queens.
- Nests made outside are found under rocks, logs, or inside decaying wood. Inside, the species nests in wall voids and behind baseboards—it is very commonly found close to water sources in the kitchen and bath.
- Ant body size is so small that these ants can enter packages through seams and freely exit from electrical outlets.
- Workers follow well-defined foraging trails along baseboards, inside cabinets and closets, and along walls. Electrical wiring is commonly followed from room to room.

FOOD PREFERENCES

- Thief ants feed on living ant larvae, dead insects, honeydew, germinating seeds, meat, cheese, peanut butter, and grease (also known as "grease ants").
- Thief ants also feed on rodent carcasses, making them potential disease vectors.

Ant Management

There are four approaches available to you for managing ant infestations:

1. Pest proofing and sanitation;
2. Barrier treatments;
3. Treating the nest directly; and
4. Using baits as a way of delivering pesticide into the nest.

The combinations of these four approaches that you use will depend on the species present, the results of your initial site inspection, and any previous management efforts.

Inspection

The ant colony is the source of all the individual ants that your clients will encounter, whether they are workers foraging for food or swarmers flying in the structure. Finding the nest, or at least determining that it is not in the building, is the primary goal of your inspection. Foraging ants carrying bits of food should be followed as they return to the colony.

Indications of an indoor nest site include consistent ant foraging over a long period of time, nest materials (e.g., wood shavings) observed inside, ant foraging during the winter, foragers in a high-rise building, or swarming of winged ants. Using sticky traps may prove helpful (Figure 4.7 A). Outside nesting is indicated by worker trails that lead outside and nesting sites (e.g., soil mounds or wood shavings) next to the foundation.

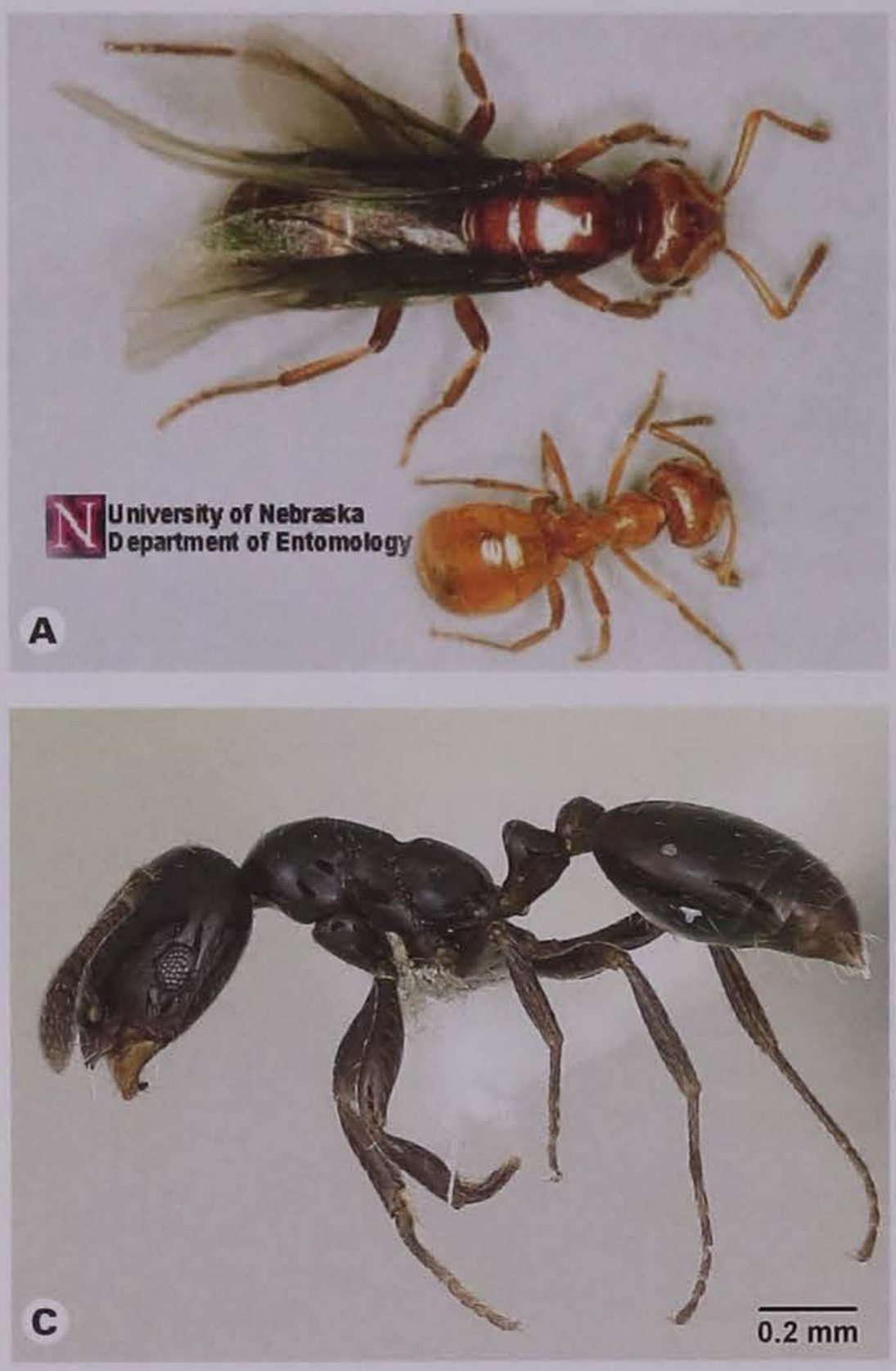


Figure 4.6. (A) Larger yellow ant; (B) Larger yellow ant swarm; (C) Little black ant; (D) Odorous house ant; (E) Odorous house ant feeding on scale honeydew; (F) Pavement ant. Image credit: (A) Jim Kalisch, University of Nebraska-Lincoln; (B) Steve Wilson, www.bluejaybarrens.blogspot.com; (C and F) April Nobile, http://antweb.org; (D) JJ Harrison, Wikipedia Creative Commons; (E) Susan Ellis, Bugwood.org

Figure 4.6. (G) Pavement ant head, showing distinctive grooves; (H) Pharaoh ant; (I) Pharaoh ant feeding mass; (J) Thief ant; (K) Thief ant relative size. Image credit: (G) April Nobile, http://antweb.org; (H) Naturhistorisches Museum Wien, www.antbase.net; (I) www.denverlancaster.com; (J) www.advantagetpc.com/; (K) Laura Jesse, Iowa State University Extension and Outreach

Sometimes locating the nest is not possible. Alternatively, you can learn more about the ant activity by identifying foraging trails in the account. Are ants coming from outside a building, from under a slab, or from somewhere in a wall? Taking the time to assess foraging activity is a crucial part of the inspection.

Note site conditions that are attractive to ants. Poor sanitation, insufficient seals around doors and windows, water-damaged wood, or cracks in the foundation are among the items to look for.

Pest Proofing and Sanitation

A building is a part of an ant's environment and it will explore much of its surroundings to find food, water, and new nest sites. One way to prevent ants from foraging or nesting indoors is to build them out. Sealing around doors and window frames (Figure 4.7 B), pipes penetrating the building envelope, and cracks in the foundation go a long way to keeping ants outside. Other methods include having tightly fitting doors and window screens, repairing siding or shingles, and draining water away from buildings.

Sanitation is especially important in accounts where pest proofing is difficult to achieve (e.g., poorly maintained older homes, public schools, and commercial buildings built on slabs). Ants will stop foraging in an area when their efforts are fruitless. One achievable sanitation goal is for the building occupants to keep the kitchen and break areas extra tidy and clean in the spring and summer, when many ants seek out food sources and establish trails (Figure 4.7 C).

Barrier Treatments

A barrier treatment is an alternative if pest proofing and sanitation have not solved the problem and the nest cannot be located. Although some worker ants will be killed by the residual insecticide treatment, this method mostly serves as a repellent. Properly applied, it should even stop ants from using well-established foraging trails.

The product label will provide valuable information as to how to do a barrier treatment:

- Distance from the foundation outward; 4 to 10 feet is common
- Height up the foundation the treatment should be made; 3 feet is common
- Possible need to treat shrubs, mulch, and perennial plants within the treatment zone
- Possible requirement to water in a granular insecticide
- Specific sites for treatment, including under siding where it overlaps the foundation, under doorjambs, sill plate in the **crawlspace**, and any visible cracks or crevices

Effective formulations include wettable powder, suspension concentrate, and microencapsulation, especially on brick veneer homes.

Barrier treatments are temporary solutions and may need to be repeated (as per label directions) when ants are seen in the treated area. This need to repeat the application, as well as the relatively large area treated and amount of insecticide required, explains why barrier treatments are NOT the first choice for ant control.

If ants continue to be a problem indoors after a barrier treatment has been made, then either the colony is nesting indoors or the ants are getting access to the building from above (e.g., telephone wires, overhanging tree branches) or below the ground (e.g., tree roots, pipes, utilities, structural cracks). Re-examine the possible nesting sites or access points to the structure.

Treating the Nest

Once located, use a residual insecticide to treat a nest. Outdoors, you can use liquid or granular products. If you use a liquid, be sure to use enough water to thoroughly drench the material into the nest. To treat a carpenter ant nest in a tree cavity, you may need to drill an access point at the top of the nest and then apply the liquid.

Indoors, aerosols and dusts are the preferred formulations. Use aerosols if you uncover the nest during an inspection. Spray all of the ants before they get a chance to disperse. Dusts are chosen when nests are located in voids and in areas involving electrical wiring. Dusts provide a long residual effect, so not only current ants but also future ants are killed. You may need to drill holes in floors, walls, or ceilings to gain access to the void in which the nest is located. Use wood putty to plug these holes after treatment.

Baiting

Nontoxic ant baits can be used to determine the focus of an infestation or to locate small, isolated colonies. This baiting can also help you determine what type of food (e.g., sweet, protein, grease) the foragers are taking back to the colony.

Ant baits containing slow-acting insecticides are taken back to the colony by foragers. The products have to be slow acting to give the ants time to return to the nest and share the bait with other workers, brood, and the queen(s). Baits allow for elimination of the colony without having to find and treat the nest directly.

The key to bait success is acceptance. Avoid any actions that will prevent ants from accepting the bait and taking it back to the colony. For example, using a residual insecticide near bait may act as a repellent or kill the foragers directly.

Sanitation is also important for bait acceptance. If ants have plentiful food sources available, they will choose those foods over the bait. Sanitation, though, does not remove natural food sources (e.g., honeydew, carrion, dead insects) that will always compete with baits.

Place baits as close to foraging trails as possible to increase the chances ants will take the bait. If pre-baiting reveals ants are taking two types of foods, set out different baits (even side by side) along trails or near nest sites. Be sure to place enough baits, both to increase the chance ants will find the bait and to ensure that enough bait is returned to the nest to provide control.

Baits come in several formulations. Liquid and gel baits are sugar baits. Granules, pastes, and liver baits offer protein to ants. Yellow oily baits provide lipids.

- Liquid baits (Figures 4.7 D, E). Come pre-baited or can be added to stations. These require maintenance due to evaporation, which increases the concentration of the toxicant and chances that the bait will kill the foragers before they return to the nest. One improvement is to use covered stations or stations with foam tops. Ants can feed through the foam without the risk of falling into the bait and dying. A similar strategy would be to put bait in a vial and plug it with a piece of cellulose kitchen sponge.
- Gel baits (Figure 4.7 F). Come in tubes and can be injected into stations or placed directly on surfaces. These baits require less maintenance than liquids and are easy to use, which makes them popular among PMPs.
- Granular baits. Used for ants that nest in the soil, leaf litter, or mulch. Place bait around active mounds or near ant trails. Avoid placing granules directly on the mounds, as this will alarm the ants and lead to bait rejection. If you are unsure of colony locations or if there are a large number of colonies in an area, you can apply granules as a broadcast treatment. Make sure this equipment is dedicated to this purpose, as equipment used to apply other chemicals will impart odors and lead to bait rejection.

ACTIVE INGREDIENTS

There are several insecticides registered for ant control. Some products have a single active ingredient while others are combinations of two or more actives. Consult the product label to determine if that insecticide can be used to control the ants on the specific site(s).

For barrier and/or nest treatments (and some baits), the active ingredients include azadirachtin, azoxystrobin, *Beauveria bassiana*, carbamates (baygon, carbaryl), chlorfenapyr, difenoconazole, fipronil, insect growth regulators (ethofenoprox, methoprene, pyriproxyfen), neonicotinoids (acetamiprid, clothianidin, imidacloprid, thiamethoxam), organophosphates (acephate, chlopyrifos, malathion), pyrethrins, pyrethroids (bifenthrin, bioallethrin, cyfluthrin, cyhalothrin, cypermethrin, cyphenothrin, deltamethrin, esfenvalerate, fluvalinate, permethrin, phenothrin, prallethrin, tetramethrin, tralomethrin), and sodium o-phenylphenate.

The primary bait active ingredients include arsenic trioxide, avermectins, borax, boron sodium oxide, dinotefuran, hydramethylnon, indoxacarb, silicon dioxide, and thiamethoxam.

Special Management Considerations

Two pestiferous ant species require special considerations to achieve complete control.

PHARAOH ANTS

Management of this species must be done knowledgably or the problem will become worse. Applying the wrong pesticides, or even the wrong formulation, will cause the colony to bud into several colonies; this results in the ants infesting several new locations. After an application, the colony will disappear and give the impression that the colony has been destroyed. However, 7 to 10 days later, new colonies are reorganized and the ants will continue their foraging activities. Proper identification is crucial for this ant species. Pre-bait with non-toxic mint jelly when necessary. Newer Pharaoh ant baits do not require pre-baiting. Baiting is the most reliable method for controlling this species. Place one bait station per foraging trail, near the entry/exit point of the wall or nest area. Do not disturb or agitate the ants because they may move the nest.

CARPENTER ANTS

Carpenter ants can best be controlled by direct dust treatment of the nest. Baits can be used to control this species if the nest cannot be located or is inaccessible (e.g., high in a tree). Baiting will likely take more time and more frequent visits, so discuss this with your client. When baiting for carpenter ants, place baits near the base of a tree from which foragers emerge. This will reduce foraging pressure on the structure and will result in foraging trails also away from the structure. Gel baits can be very effective against worker ants that are seen indoors in the winter.

Figure 4.7. (A) Ants on insect sticky trap; (B) Sealing a window frame; (C) Overflowing garbage is attractive to ants; (D and E) Response of ants to baits; (F) Commercial ant bait example. Image credit: (A) www.pestservice.co.uk; (B) www.helpsaveearth.org; (C) Vicky Kane, Wordpress.com; (D) www.narragansettpestcontrol.com; (E) Becky Crew, www.runningponies.com; (F) www.backedbybayer.com/

Chapter 5
Nuisance Flies

Learning Objectives

After studying this chapter, you should be able to

- Explain the human health concerns from nuisance flies
- Describe the general life cycle of flies
- Identify the distinguishing physical features of flies
- Distinguish between: house fly; cluster fly; blow fly
- Contrast the breeding site preference for: vinegar fly; moth fly; humpbacked fly; fungus gnat
- Predict how an unkempt food service area could hamper pest control efforts against nuisance flies
- Discuss two types of traps that can be used in nuisance fly pest management
- Explain the role of chemical products in fly management

General Biology

Several types of flies may be found in and around homes. Most of these are invaders from outdoors while a few are produced indoors in specific situations. The flies discussed in this chapter are considered an annoyance and a possible indication of unsanitary or unpleasant conditions. There is a slight possibility that flies can mechanically transfer disease-causing organisms. These flies do not bite or sting humans, nor do they feed on furnishings or structural elements in a facility.

Flies have a complete life cycle (Figure 5.1 A). Flies have very specific requirements for egg-laying sites where larvae will develop. Maggots (fly larvae) have chewing mouthparts, are legless, and usually white or off-white in color. Pupae are usually encased in a brown, capsule-like structure. Adults have one pair of wings and are highly mobile. Adult flies have sucking or sponging mouthparts that project downward from the head (Figure 5.1 B). Solid food must be liquefied with saliva secreted from the mouthparts before it can be ingested.

Fly Pests in/around Structures

House Fly (*Musca domestica*)

The house fly is the most common fly species found in and around homes and many other types of buildings.

IDENTIFICATION

- The adult fly is ¼ inch (6 mm) long.
- Adults have a dull gray thorax with four lengthwise dark stripes, and a dark abdomen (Figure 5.1 C).

LIFE CYCLE

- Female flies lay eggs in garbage, animal manure, rotting fruits and vegetables, or other decaying organic matter.
- Eggs are laid in clusters containing 100 or more eggs. These eggs hatch in 1 to 2 days.
- The complete life cycle can occur within one week under warm, ideal conditions.
- In the upper Midwest, house flies usually are present from May through October, during which time they produce many generations.
- They overwinter as larvae or pupae in sites where **microbial fermentation** or domestic heating prevent the breeding material from freezing.

HABITS

- During the day, house flies can be found near breeding sites and sources of food and moisture. At night, house flies rest on stationary objects, such as wires, fences, vegetation, and the sides of buildings.

Cluster Fly (*Polienia rudis*)

Often mistaken as the house fly, the cluster fly is regularly seen indoors flying near windows and lights during warmer days of winter.

IDENTIFICATION

- Flies are 9/32 inches (7 mm) long.
- Adults have fine yellow or gold hairs on the thorax (Figure 5.1 D)

LIFE CYCLE

- Females lay eggs in the summer on the soil of lawns, fields, and gardens. The larvae hatch and parasitize earthworms.
- A complete life cycle takes 4 to 6 weeks with two or more generations being produced each year.
- Adults overwinter behind tree bark, in hollow trees, in cracks of logs or wood poles, under rocks, and most commonly inside buildings.
- Adult flies enter structures in September and October; the south and west facing sides of the building are well-known entry sites. Individuals cluster in wall voids, attics, and in window or door casings, thus explaining their common name.

HABITS

- On warmer, sunny days of winter or early spring, these flies buzz around noisily and sluggishly indoors. They will fly into lights and windows, often colliding with objects and falling to the ground to spin on their backs buzzing loudly.
- Dead flies that accumulate in buildings become food for other pests, such as ants, carpet beetles, and larder beetles.

Blow Flies, Bottle Flies, Flesh Flies

The term blow fly is used to describe several species of related flies, all in the family Calliphoridae. The color of the blow fly or bottle fly varies from metallic green, blue, bronze, or black and is characteristic of the species (Figure 5.1 E). Flesh flies are in the family Sarcophagidae and are gray with three dark stripes on the thorax and a black checkerboard pattern on the abdomen.

IDENTIFICATION

- All flies in this group are similar in size; lengths range from 1/4 to 9/16 inches (6 to 14 mm).

LIFE CYCLE

- Adult flies are attracted to the putrefying odors of animal carcasses (e.g., rodents in wall voids, bats in attics, raccoons in chimneys, feral cats or dogs beneath a structure in a crawlspace).
- Female flies lay clusters of 40 or more eggs on the carcass. Within hours, eggs hatch into maggots (Figure 5.1 F) that feed on and develop in the dead animal tissue. When fully developed, the creamy white maggots crawl away from the carcass and pupate in the soil, under debris or other objects.
- An entire life cycle can be completed in 10 to 25 days.
- These flies overwinter either as maggots, pupae, or adults, depending on the species.

HABITS

- Adult flies are active only during daylight hours, when they can be found near breeding sites and sources of food and moisture. At night, these flies rest on stationary objects such as wires, fences, vegetation, or the sides of buildings.
- Adult blow flies can disperse more than 10 miles in search of food and breeding sites.
- Under certain conditions, these flies can multiply rapidly and annoy a community's residents.
- Their direct association with animal carcasses can constitute a public health hazard.

Vinegar (Fruit) Fly (*Drosophila melanogaster*)

These flies are very small, slow flying, and are named based on their food source.

IDENTIFICATION

- Flies are 1/16 to 1/8 inch (1.5 to 3 mm) long.
- Adults have a yellowish brown body, alternating light and dark stripes on abdomen, and red eyes (Figure 5.2 A).

LIFE CYCLE

- Females lay eggs in overripe or fermenting fruits and vegetables and in food residues that have accumulated in garbage, pop can, or recycling containers. They also lay eggs in refrigerator drain pans, around slow plumbing leaks, and in the fermenting slime in kitchen sink drains and garbage disposals.
- A single female can lay 500 eggs. Maggots hatch from eggs within one day and develop in moist decaying plant matter; larval development can occur in 5 days under ideal conditions.
- The complete life cycle can occur within 8 days, with several generations produced per year.

HABITS

- Fruit flies are especially annoying when they hover over food sources.

Moth Fly (*Clogmia albipunctata*)

Also called drain fly, sewer fly, or filter fly, this species is named for its fuzzy appearance and breeding site preference.

IDENTIFICATION
- Flies are ⅛ to ¼ inch (3 to 6 mm) long.
- Adults are dark gray or black (Figure 5.2 B).
- Wings are prominent and covered with hairs, giving them a moth-like appearance. Wings are held over body at rest giving them a triangular look.

LIFE CYCLE
- Females lay clusters of 30 to 100 eggs on the surface of the decaying organic slime layer that forms in floor drains, sewers, overflows on sinks and pools, and evaporation trays of refrigerators and air conditioners.
- Eggs hatch within one day.
- Life cycle is completed in 2 to 3 weeks; several generations are produced per year.

HABITS
- Adults are poor fliers and are easily blown long distances away from breeding sites.
- Adults are most active in the evening.

Humpbacked Flies

Small flies are in the family Phoridae with several common names, including phorids flies, coffin flies, and scuttle flies.

IDENTIFICATION
- Flies are 1/16 to ¼ inch (1.5 to 6 mm) long.
- Adults are yellowish brown to black, with black eyes.
- The thorax is characteristically hump-shaped when viewed from the side (Figure 5.2 C).

LIFE CYCLE
- Females lay eggs (20 at a time) on or near moist and decaying organic matter.
- Eggs hatch within one day.
- Life cycle is completed in 2 to 5 weeks.
- Common breeding sites include floor drains, trash containers, elevator pits, and garbage disposals, and where drain or sewage pipes have broken under slabs or in crawl spaces. Alternate sites include dirty floor mops, janitor closets, laundry rooms, pet rodent bedding, septic systems, and mortuaries (flies infesting human cadavers).

HABITS
- Adults are strong fliers but their first escape mechanism is to actively run across a surface rather than flying.
- Flies have been observed running rapidly across windows, television screens, tables, and walls in short, jerky movements (Figure 5.2 D).

Fungus Gnats

These tiny, nuisance flies are members of the families Mycetophilidae and Sciaridae.

IDENTIFICATION
- Flies are 1/16 to 1/8 inch (1.5 to 3 mm) long.
- Adults are black.
- These delicate insects resemble mosquitoes. They have slender legs, segmented antennae longer than the head, a head slightly tucked under the thorax, and wings light gray to clear (Figure 5.2 E).

LIFE CYCLE
- Females lay eggs in moist, organic debris or potting soil.
- Maggots have a shiny black head and an elongate, white, legless body (Figure 5.2 F).
- Many generations per year are possible under ideal conditions.
- Common outdoor breeding sites include organic mulch, leaf mold, grass clippings, and compost. Indoors, larvae are often found in overwatered plants, in wet insulation under flat roofs, or in pet bird feces when not cleaned regularly.

HABITS
- Fungus gnats can be problematic in greenhouses, nurseries, and sod farms because maggots will feed on plant root hairs.
- Adults are attracted to lights and may be drawn into a structure from outdoor breeding areas.
- Adults feed very little, consuming only liquids (e.g., water, flower nectar).

Figure 5.1. (A) House fly life cycle; (B) House fly mouthparts; (C) House fly; (D) Cluster fly; (E) Green bottle fly; (F) Blow fly maggots. Image credit: (A) Clemson University-USDA Cooperative Extension Slide Series, Bugwood.org; (B) glsammy, FLICKR.com; (C) Juergens Peters, Diptera.info; (D) www.prokill.co.uk; (E) Morten Pedersen, photo.dv.no; (F) Susan Ellis, Bugwood.org

Figure 5.2. (A) Vinegar fly; (B) Moth fly; (C) Humpbacked fly; (D) Scuttle fly dance; (E) Darkwinged fungus gnat; (F) Fungus gnat larvae. Image credit: (A) Muhammad Mahdi Karim, www.micro2macro.net; (B) Sanjay Acharya, Wikipedia; (C) Roger Thomason, www.diptera.info/photogallery.php; (D) Roger Thomason, www.diptera.info; (E) David Cappaert, Michigan State University, Bugwood.org; (F) Whitney Cranshaw, Colorado State University, Bugwood.org

Fly Management

Sanitation

Sanitation is the single most important step in controlling flies because it removes both food and breeding sites. It is best to involve the customer whenever possible. Small amounts of garbage or organic waste can support hundreds of developing flies (Figure 5.3 A). Regular cleaning of the facility and deep cleaning of kitchen and break rooms is very important in decreasing food for fly development. Pay attention to edges and corners of a room and under equipment, as food debris builds up in these areas. Clean out floor drains regularly using a stiff brush and/or a biological product formulated for this purpose. Fix plumbing leaks as discovered.

Also, sanitation includes disposal of excrement, garbage, animal carcasses, proper storage of waste materials, and adequate drainage (interior and exterior) (Figure 5.3 B). "Gray" wastewater is highly attractive to flies. Clean garbage cans and dumpsters regularly with steam cleaning or pressure washing. Move garbage cans and dumpsters as far away from the exterior of the building as practical. It is best to keep these containers covered to prevent them from attracting flies. Trash should be removed from the site weekly from residences and non-food businesses, and daily from restaurants and similar businesses. Open sewage pits and wastes from food-based industries are sources of heavy fly breeding and can cause more problems in nearby residential areas. Broken septic or sewer lines require soil excavation, removal of all the leaked sewage, and repair.

Inspection

A detailed facility and site inspection must occur to find and eliminate all fly breeding sources. These investigations should begin inside a building, and then move to the exterior foundation, landscaping, and neighboring properties. Adult flies will typically lead you to the breeding sites, as these insects are highly attracted to odors associated with breeding materials. Failure to eliminate breeding sources will negate any other attempted control methods.

Exclusion

Another very important nonchemical method of preventing fly problems in buildings is exclusion. Exterior doors and windows should be tight-fitting, properly screened, and kept closed whenever practical. Plastic strip curtains, air doors, and self-closing doors can be used to deter fly entry into a structure. Seal and tighten around all openings such as doors and windows, plumbing entries, ventilators, and eaves (Figure 5.3 C). Inspect around the soffit and wall junction and the soffit face board, and look for loose siding boards; seal gaps as they are found.

Traps

Once flies are inside a building, electric light traps can be used to capture winged adults. These traps usually employ ultraviolet light as an attractant, and kill either by electrocution or entrapment on replaceable glue boards (Figure 5.3 D). Carefully follow manufacturer's directions for trap use and maintenance. In order for these traps to be effective, they must be properly positioned along routes of fly entry and movement. They must be installed at the proper height (usually within 5 feet of the floor) and away from windows and other competing light sources. The glow of the light trap should not be visible from outside the structure; otherwise the trap will attract insects into the building when doorways are open.

Bottle or jar traps can be used to capture adult flies for identification purposes. Bottle traps are especially useful for trapping vinegar flies and humpback flies once the breeding source is eliminated. You can make a simple jar trap by placing a paper funnel into a jar containing a few cotton balls (to reduce evaporation) and then adding a few ounces of cider vinegar or fermenting substance as the bait.

Chemical Controls

Insecticide sprays may temporarily reduce the numbers of flies, but this method will not eradicate a problem. Space sprays provide very brief control. These non-residual contact sprays provide quick knockdown of adult flies, but do not affect developing maggots. Active ingredients include synergized pyrethrins and pyrethroids (e.g., allethrin, sumithrin, resmethrin). Application can be made with aerosol-type dispensers, ultralow volume, or fog-generating equipment. For optimum results indoors, apply the precise amount of material per cubic area specified on the pesticide label. Read the product label for the appropriate personal protective equipment. All food should be put away while utensils and food preparation surfaces should be covered before spraying.

Residual sprays or dusts in resting sites or entry points can be helpful, especially outdoor sprays in mid-September to prevent entry by cluster flies (Figure 5.3 E). Treatments should be applied as coarse, low-pressure sprays where flies rest and will most likely absorb a lethal dose (e.g., around garbage dumpsters or sun-exposed walls adjacent to a doorway). Wettable powder and microencapsulated formulations are very effective for this purpose. Pyrethroid insecticides (e.g., cypermethrin, cyfluthrin) are the most common active ingredients used for residual treatments.

Fly baits are a mixture of toxicant and attractant and are used primarily to control house flies (Figure 5.3 F). Most bait contains sugar and the house fly sex pheromone, muscalure. This combination keeps the fly in contact with the toxicant for a longer time. Fly baits are typically formulated as granules that are placed in shallow trays or scattered around dumpsters and other fly-breeding areas. Their effect is short-lived unless the bait is re-applied.

F

Figure 5.3. (A) Vinegar fly breeding materials; (B) Trash pickup; (C) Window screen needing repair; (D) Ultraviolet light trap; (E) Residual spray applied to fly resting sites; (F) Example of a commercial fly trap. Image credit: (A) Therealbrute, http://missionlocal.org/; (B) AlbanyNY.org; (C) Marcello, http://windowscreen.info/; (D) http://aircurtainmanufacturers.com; (E) www.rivercitypc.net/pest-control/; (F) www.centrallifesciences.com

Chapter 6
Stored Product Pests

Learning Objectives

After studying this chapter, you should be able to

- List when food pantry pests can infest food
- Identify items commonly infested by: Indian meal moth, drugstore beetle, rice weevil, larder beetle, booklice
- Name the damaging stage(s) of: granary weevil, carpet beetles, silverfish
- Distinguish between:
  - Red flour and confused flour beetles
  - Sawtoothed grain beetle and rice weevil
  - Larder beetle and carpet beetles
  - Casemaking and webbing clothes moths
  - Silverfish and firebrats
- Name the protein that fabric pests can digest and use for food
- Discuss how source reduction and prevention affect stored product pest management
- Outline the pesticide formulations that could be used against stored product pests and where they would be applied

Food Pantry Pests

Nearly all food products may be attacked by one or more of the many insects collectively referred to as pantry pests. They eat or contaminate the products and may make them unfit for human consumption.

Infestations can occur at every point between origin and final use. Insect pests can infest food:

- in the field as grain;
- stored by the producer or grain elevator;
- in the process of converting raw commodities into food;
- at some stage in transportation;
- while stored in a warehouse or a retail outlet; and
- when being stored prior to consumption.

Most commonly, insect pests become problems in foods that have been kept for some time, often beyond their expiration date. Pantry pests can infest rooms other than the kitchen. When this occurs, they are likely feeding on ornamental seed or plant displays, dried flowers, ornamental corn, potpourri, or even rodent baits.

The common stored-food pests are types of beetles and moths. Both groups of insects have a complete life cycle. Several generations can be produced each year. All stages are present in food pantries, though adults commonly leave the infested products and move about inside a structure. Beetles or moths may be seen a considerable distance from the infested food.

Indian Meal Moth (*Plodia interpunctella*)

The Indian meal moth is the most common moth infesting stored foods.

IDENTIFICATION

- Adult moths are ⅓ inch (8.5 mm) long with a wingspan of ¾ inch (19 mm). Larvae are ½ inch (16 mm) long.
- Outside wings of adults are characteristically two-toned with the half nearest the head tan or gray and the outer portion reddish brown or coppery (Figure 6.1 A). Scales on the wings come off easily leaving a "smudge of powder" after the moths have been swatted. Adults are weak fliers and may be seen in the kitchen and adjacent rooms.

- Larvae are off-white in color or may retain the color of the foods they consume. Larvae spin large amounts of silk webbing in and over the food. When larvae are ready to pupate, they leave the food and wander in search of a place to pupate; these sites include bag seams, cracks or crevices, in the top of the cabinet, and where the ceiling and wall meet (Figure 6.1 B).

COMMONLY INFESTED FOODS

- Foods include cereal products, crackers, dried beans, nuts, dried fruits, chocolate, bird seed, dry pet food, and tea.

Red Flour Beetle (*Trilobium castaneum*) Confused Flour Beetle (*Trilobium confusum*)

These two small (⅛ inch; 3 mm) beetles are considered serious pests in flour. Both are elongated, flat, shiny, reddish brown insects.

IDENTIFICATION

- There are three ways to distinguish them:
  - Red flour beetle (Figure 6.1 C)
    - Most common of the two; primarily in homes
    - A strong flier
    - Last three antennal segments form a distinct club
  - Confused flour beetle (Figure 6.1 E)
    - Typically found in food-processing facilities
    - Does not fly
    - Last four antennal segments gradually enlarge
- Larvae are ¼ inch (6 mm) with a long, slender body; creamy white with a brown head and dark two-pointed fork on the tip of the last body segment (Figure 6.1 D). Their small size allows entry into closed containers. They may impart a bad odor that affects the taste of infested products.

COMMONLY INFESTED FOODS

- Foods include cereal products, seeds, nuts, spices, and dried fruits.

Sawtoothed Grain Beetle (*Oryzaephilus surinamensis*)

This small food pantry pest is easy to identify and readily penetrates tightly sealed packaging.

IDENTIFICATION

- Beetles are 1/10 to 1/8 inch (2.5 to 3 mm) long.
- Adults are elongate, dark brown, flattened beetles with six sawtooth-like projections on each side of the thorax (Figure 6.1 F).
- Larvae are dirty white and less than 1/8 inch (3 mm) long with a cigar-shaped body.

LIFE CYCLE

- Females place eggs singly or in groups in the crevices in the food supply, but may be laid freely in flour.
- Beetles can produce up to seven generations per year. The greatest survival occurs when the relative humidity exceeds 70 percent.

COMMONLY INFESTED FOODS

- Sawtoothed grain beetles can infest all foods of plant origin, especially grain and grain products, nuts, dried fruits, herbs, and spices; chocolate and other candies; and dried meats.
- These insects contaminate more food than they consume, and usually are discovered leaving the infested food to crawl about the structure.
- Although they do not fly, sawtoothed grain beetles are capable of chewing into unopened paper or cardboard boxes, through cellophane, plastic, and foil-wrapped packages. Beetles are able to attack the germ of whole grains.

Figure 6.1. (A) Indian meal moth adult; (B) Larva and pupae of Indian meal moth; (C) Red flour beetle adult; (D) Red flour beetle larvae; (E) Confused flour beetle; (F) Sawtoothed grain beetle. Image credit: (A) www.animalphotos.me; (B) Whitney Cranshaw, Colorado State University, Bugwood.org; (C) Peggy Greb, USDA Agricultural Research Service, Bugwood.org; (D) Jared Kunz, Utah State University; (E) Pest and Diseases Image Library, Bugwood.org; (F) Marcello Romano, Forum Entomologi Italiani

Cigarette Beetle (*Lasioderma serricorne*)
Drugstore Beetle (*Stegobium paniceum*)

These two small (1/10 inch; 2.5 mm) beetles are oval, reddish brown in color with a humpbacked appearance and a downward pointed head.

IDENTIFICATION

- There are two ways to distinguish them:
  - Cigarette beetle—named for damage done to stored tobacco
    - Unlined wing covers (Figure 6.2 A)
    - Readily flies
  - Drugstore beetle—named for feeding on pharmaceuticals
    - Wing covers lined with rows of punctures (Figure 6.2 C)
    - Seldom flies
- Larvae are c-shaped grubs about 1/8 inch (3 mm) long; yellowish white with a light brown head (Figures 6.2 B, D).
- Adults are attracted to windows or other light sources and are often first noticed in these locations.

COMMONLY INFESTED FOODS

- Beetles invest all types of dry stored food products—spices, seeds, grains, dried fruits, pet food, dried plant material, and tobacco products.
- Drugstore beetles will also feed on leather, wool, hair, books, and drugs.
- These beetles can penetrate most paper packaging and will leave exit holes in these materials when new adults emerge.

Rice Weevil (*Sitophilus oryzae*)
Granary Weevil (*Sitophilus granarius*)

These two small (1/8 inch; 3 mm) beetles have a snout (beak) on their heads and have long slender, hard-shelled, reddish brown bodies that appear pitted or scarred with tiny holes.

IDENTIFICATION

- Primary way to distinguish these two species:
  - Rice weevil has four faint yellow spots on wing covers (Figure 6.2 E).
  - Granary weevil is uniformly colored with no spots (Figure 6.2 F).

LIFE CYCLE

- Female lays eggs inside the grain kernel. Larvae are small, white, wrinkled grubs that develop inside the kernel; adults chew exit holes when they emerge.

COMMONLY INFESTED FOODS

- Whole grains and seed are included: food seeds or beans in cupboards, popcorn, saved garden seeds, dried seed decorations, Indian corn, old bean bags, old grain-based rodent bait, or bird seed.

Fabric Pests

Fabric pests are unwelcome in homes, businesses, and museums because they will eat a variety of items (fur, feathers, piano felts, upholstery, clothes, animal collections, and carpeting). They are unique scavengers because they have the rare ability to digest keratin and use it for food. Keratin is a protein found in animal hair, fingernails, hooves, skin, wool, hide, and bird feathers.

Both beetles and moths undergo a complete metamorphosis. The larval stage causes the damage, but the first sign of infestation is usually the presence of adults in an area.

Carpet Beetles

IDENTIFICATION

- Several species are generally referred to as "dermestids."
  - Black carpet beetle (*Attagenus unicolor*) (Figure 6.3 A) – black to reddish brown with short, sparse fine hairs on thorax and wing covers
  - Larger cabinet beetle (*Trogoderma inclusum*) (Figure 6.3 B) – black with reddish brown, brown, and grayish scales on head, thorax, and wing covers
  - Varied carpet beetle (*Anthrenus verbasci*) (Figure 6.3 C) – white, brown, and yellowish scales on the head, thorax, and wing covers
  - Warehouse beetle (*Trogoderma variable*) (Figure 6.3 D) – black with varying patterns of brown or yellow scales
- Adult beetles are typically ⅛ to ¼ inch (3 to 6 mm) long.
- Larvae are from ¼ to ½ inch (6 to 12 mm) long, cigar-shaped, and covered with yellow, brown, or black hairs (Figure 6.3 E) that lay flat on body or are erect, depending on species. Larvae are slow moving.

COMMONLY INFESTED ITEMS

- Carpet beetles feed on a wide variety of animal and plant materials, including hair, fur, feathers, horns, bird carcasses, dead insects, wool carpeting or stored woolen materials, and dried meats.

- Cabinet and warehouse beetles are more likely to be found in grain products, cereals, seeds, candy, dried fruits, nuts, dried milk, and pet foods. These beetles also feed on wool clothing and dead insects.

Larder Beetle (*Dermestes lardarius*)

This beetle is a very common and widespread structural pest. The name is derived from its presence in dried, cured meats stored at room temperature prior to refrigeration (larder = "a place where food is stored").

IDENTIFICATION

- Beetles are ¼ to ⅜ inch (6 to 9.5 mm) long.
- Adults are elongate and oval, dark brown or black with a characteristic yellow band across the wing covers. This light colored band has from six to eight black spots on it (Figure 6.3 F).

- Larvae are ½ to ⅝ inches (12 to 16 mm) long, dark brown with long brown hairs. There are two upward curved spines on the posterior end. Mature larvae wander to find something solid to pupate in, bore into wood or something similar to make a pupal chamber, and then plug the hole with the last molted skin.

COMMONLY INFESTED ITEMS

- Larder beetles infest fur, hair, hides, animal trophies, feathers, dried fish, pet food, cheese, dead insects, and rodent and bird carcasses.
- These insects are important natural "recyclers" that play an important role in the breakdown and recycling of animal protein.

Clothes Moths

Clothes moths, once well-known and common pests of fabrics in the home, are rarely encountered today. Carpets made of synthetic fibers are not attacked by clothes moths and an increase in dry cleaning has decreased the pests' incidence.

IDENTIFICATION

- Adult moths are ¼ inch (6 mm) long with a wingspan of ½ inch (12 mm).
- Larvae are ½ inch (12 mm) long; white with brownish black heads.
- There are two species of clothes moths:
  - Casemaking clothes moth (*Tinea pellionella*) – wings and body are buff to golden in color and there are three dark spots on each forewing. The hind wings have a fringe of long hairs. Larvae construct a portable case of silk and bits of fiber (Figures 6.4 A, B).
  - Webbing clothes moth (*Tinea bisselliela*) – wing color is golden and there are distinctive hairs on the top of the head that are reddish-gold. Larvae spin silk feeding tunnels on the fabric surface as they feed.
- Adults are weak fliers that usually run ("scuttle") to hide in folds of textiles when disturbed.

COMMONLY INFESTED ITEMS

- Items include woolen clothes and rugs, hair, fur, silk, paper, synthetic fibers, cotton, felt, and feathers.
- Clothes moth larvae prefer to feed in protected locations, such as under collars, inside hems, on the backside of or in cracks of woolen carpets, used furniture, and inside storage containers. Rarely will these insects be found infesting garments or items that are used or moved regularly. If larvae are permitted to feed, they chew holes of various sizes in garments, carpets, and other fabric items.

Figure 6.2. (A) Cigarette beetle adult; (B) Cigarette beetle larva; (C) Drugstore beetle adult; (D) Drugstore beetle larva; (E) Rice weevil; (F) Granary weevil. Image credit: (A) USDA Agricultural Research Service; (B) www.nbaii.res.in; (C and D) USDA Agricultural Research Service; (E) Olaf Leillinger, Wikipedia Creative Commons; (F) Pest and Disease Image Library, Bugwood.org

Figure 6.3. (A) Black carpet beetle, adult and larva; (B) Larger cabinet beetle adult; (C) Varied carpet beetle adult; (D) Warehouse beetle, lower and upper views; (E) Surface hairs from warehouse beetle larva; (F) Larder beetle adult. Image credit: (A) Clemson University, USDA Cooperative Extension Slide Series, Bugwood.org; (B and E) Pests and Diseases Image Library, Bugwood.org; (C and F) Joseph Berger, Bugwood.org; (D) Jared Kunz, Utah State University

Paper Pests

Some insects can feed on paper, wall coverings, paperboard, and books. They can cause problems in homes, business files, libraries, and museums.

Silverfish (*Lepisma saccharina*) Firebrats (*Thermobia domestica*)

All members of the order Thysanura have a body shaped like a flattened carrot, with the head being broad and the body tapering down to a narrow posterior end. There are three long bristles or "tails" on the tip of the abdomen. These are small insects, ½ inch (12 mm) long at maturity.

IDENTIFICATION

- Two thysanurans occur in structures:
  - Silverfish (Figure 6.4 C) – They are covered with shiny silver scales that give the body a metallic sheen. They seek moisture and are commonly found in sinks and bathtubs because they cannot climb out. Silverfish are most active at night and run very swiftly with a wiggling motion that resembles the swimming action of a fish.
  - Firebrats (Figure 6.4 D) – Their body is gray or brown, usually with numerous dark markings that give the insect a mottled appearance. The pests are commonly found in areas of high temperature (90° F) and high humidity, such as in attics, around furnaces, boilers, ovens, and water heaters.

LIFE CYCLE

- These insects undergo gradual metamorphosis.
- Unlike other insects, silverfish and firebrat adults continue to molt when full grown.
- Adults can live up to 8 years.

COMMONLY INFESTED ITEMS

- These pests infest fabric, paper, books, book bindings, wallpaper, labels, and starchy glues.
- They are considered as pests primarily because they are a nuisance—only a very large infestation that has developed over time can cause significant damage.

Booklice

These insects are very common and abundant, but, because of their tiny size, they generally go unnoticed.

IDENTIFICATION
- They are 1/20 to 1/10 inch (1.2 to 2.5 mm) long.
- Nearly colorless or light gray, they have long, slender antennae and generally resemble a termite worker but are much smaller. The bulging, squarish head distinguishes them from termite's rounded head (Figure 6.4 E).

LIFE CYCLE
- They go through gradual metamorphosis.

HABITS
- Normal habitat is outdoors in damp places (e.g., under bark, in grass, leaves, and damp wood).
- They may impact a structure by flourishing in damp basements and crawlspaces.

COMMONLY INFESTED ITEMS
- Booklice primarily feed on molds and fungi.
- They generally are not problematic but have been found infesting stored food, bird and insect nests, and moldy glue, paper sizing, and paper products.
- Book lice can be serious pests for manufacturers of food products and containers.

Management of Stored Product Pests

Management of stored product pests is somewhat dependent on the specific pest(s) present. Use of one or more of the following is recommended to properly manage the pest problems.

Inspection

Inspection is a major part of elimination of stored product pests, because they are often discovered when adults start moving around a structure. Detecting these pests is difficult because of their small size and hidden feeding sites.

- Check for pests, cast skins, and insect trails in spilled product dust or debris.
- Inspect under, around, and inside packaging for penetration and/or exit holes, as well as for insects in seams and folds.
- Investigate potential problem sites (e.g., areas where seasonal clothes are left in storage for several months).
- Seal any cracks and crevices discovered during inspection.
- Take detailed notes as you inspect.

Figure 6.4. (A) Casemaking clothes moth larva; (B) Casemaking clothes moth adult; (C) Silverfish; (D) Firebrat; (E) Booklice. Image credit: (A and D) Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org; (B) Mohammed El Damir, Pest Management, Bugwood.org; (C) Alexey Sergeev, www.asergeev.com; (E) Dave Sheltar, BugDoc, http://bugs.osu.edu/bugdoc/Shetlar

Source Reduction

There are several things that the customer can do to reduce the food attracting stored product pests in their building. Securing their cooperation and participation will speed up management efforts.

- Dispose of any food, fabric, or other infested item. If the customer wants to keep something that has been fed upon by insects (e.g., bird seed), tell them to place the item in an oven at 130° F for 30 minutes or put it into a freezer at 0° F for 3 days. Either approach will kill all life stages present.
- Improve sanitation, which is very important in managing stored product pests. Most of these insects are small and can survive on very little food. Empty cabinets and storage closets, then thoroughly clean surfaces with soap and water. A vacuum cleaner can be used to clean cracks and crevices, which can harbor both food and insects.
- Clean infested clothing by washing the item in hot water or dry cleaning. If wall-to-wall carpets or throw rugs are attacked, they may need to be removed or cleaned.
- Reduce high humidity and moisture within a building by repairing plumbing and increasing the ventilation.
- Use sticky traps that have food attractants or **sex pheromones** (chemicals released by females to attract males for mating) for some pantry pests. Traps can be used to monitor for the presence of these insects or to assist in population reduction.

Pesticide Application

In certain situations, the proper use of a labeled insecticide complements pest management efforts. Keep in mind, though, that insecticides will not solve a problem if the source is not found and eliminated.

- Very few pesticides can be applied directly to food products. If pesticides are used to control a stored product pest, food must be removed and the label directions must be followed to prevent food contamination.
- A residual crack-and-crevice or spot treatment may be required to kill wandering insects and to prevent re-infestation from wall or ceiling voids where adults have found harborage.
- Traditional insecticide dusts can be placed in attics or structural voids to control fabric pests feeding on accumulated dead insects. Inorganic dusts and microencapsulated pesticides should be used if the site has high temperatures.
- Granular baits have labels to control some stored product pests (e.g., silverfish).
- Baseboard spraying, fogging, and broad area treatments are generally ineffective and waste insecticide and the pest manager's time.
- Pesticides should not be applied to clothing. These items should be dry cleaned or washed in a clothes washer.
- Common active ingredient of insecticides used to control stored product pests include pyrethroids (e.g., bifenthrin, cyfluthrin, deltamethrin, lambda cyhalothrin, permethrin), diatomaceous earth, silica gel, and synergized pyrethrins.

Prevention

Once a stored product pest has been eliminated, you should give the customer a list of instructions to prevent re-infestation, including:

- Inspect food packaging at the time of purchase. Do not accept any package that has been ripped or damaged in any manner.
- Check the date of expiration. If the contents cannot be used before it expires, choose another package with a longer expiration date.
- Keep food storage areas clean.
- Store dried foods in tightly fitting glass, metal, or plastic containers or in the freezer (if appropriate).
- Date products after purchase and use older products first.
- Have an ongoing cleaning (or laundering or dry cleaning, where appropriate) of the facility or vulnerable items.
- Store valuable items (e.g., bridal gown, tuxedo, furs) in specialized storage containers after dry cleaning.
- Remove dead insects and nests (e.g., wasp, bird) that can be used as a food source for stored product pests.
- Use moth balls (naphthalene) or cedar wood as repellants when appropriate and permitted by product label.

Chapter 7
Accidental Invaders

Learning Objectives

After studying this chapter, you should be able to

- Define: accidental invader
- List three needs each pest species must have to survive in a site
- Identify four common places that pests can enter a structure
- Distinguish between:
  - Multicolored Asian lady beetle and boxelder bug
  - House cricket and camel cricket
  - Centipede and millipede
  - Sowbug and pillbug
- Explain why clover mites can be a problem in a structure
- Name the accidental invader that humans move into homes in bundles of newspaper, luggage, and flowers
- Identify the accidental invader often found in new homes feeding on molds growing on lumber exposed to moisture
- State the three methods used to manage accidental invaders
- Give three limitations for pyrethroid insecticide uses to control accidental invaders

Overview

The term "accidental invader" includes those pests that may occur in buildings at some stage of their life cycle, but that do not usually complete their entire life cycle within the structure. These are also called occasional invaders because they do not regularly occur inside. These pests are uniformly disliked even though they are generally harmless and cause no damage to buildings, furniture, or occupants. Some exceptions do occur; for example, multicolored Asian lady beetles can bite as well as cause strong allergic reactions in people.

"Invasion" is often triggered by migration from a nearby, heavily populated habitat. Their movement into a structure is merely accidental, often the result of foraging, but can provide all three items an organism needs to survive in a site, which are food, water, and shelter.

Common Invaders

Boxelder Bug (*Boisea trivittatus*)

Perhaps the best known of the accidental invaders, this insect is frequently a nuisance in and around homes.

IDENTIFICATION

- Bugs are ½ inch (13 mm) long.
- Their elongated oval body shape is pointed on each end and is black with red lines on the thorax and red outlines on the wings (Figure 7.1 A).

LIFE CYCLE

- These insects undergo gradual metamorphosis.
- Nymphal stages are bright red and similar in shape to the adults but smaller (⅛ to ⅜ inch; 3 to 10 mm) (Figure 7.1 B).
- They produce two generations per year.

NATURAL HABITAT, HOSTS

- This insect feeds on the sap of several trees including boxelder (*Acer negundo*) and other maple species.
- It also feeds on strawberries, apples, prune, pear, and some dead insects (including honeybees).

WHEN FOUND IN STRUCTURES

- The adults seek overwintering sites and can be found late fall through winter in structures, wood piles, and leaves, or underneath rocks, boards, and loose bark (Figure 7.1 C).

WHY CONSIDERED PESTS

- They crawl around rooms when warmed by sun or heat from a furnace. They may stain draperies or resting spots with feces or produce a foul odor when crushed. Their carcasses are fed upon by stored product pests.

Multicolored Asian Lady Beetle (*Harmonia axyridis*)

This insect is a fairly recent structural invader, but has risen to one of the top nuisance pests encountered by homeowners and other building occupants.

IDENTIFICATION

- Beetles are ⅓ inch (9 mm) long.
- Adults are oval with a domed body. They have a black "M" on the white prothorax. The wing covers color varies from pale to dark orange and may have dark spots (0, 4, 6, or 19) (Figures 7.1 D, F).

LIFE CYCLE

- They undergo complete metamorphosis.
- Larvae are flattened and elongate, often called "alligator-like," having small spines along a black body with orange markings (Figure 7.1 E).
- Females lay yellow eggs in clusters of 20 on the undersides of leaves.

NATURAL HABITAT, HOSTS

- A predator during the spring and summer, they feed on aphids, scales, and plant-injuring insects.

WHEN FOUND IN STRUCTURES

- Beetles look for overwintering sites in late September or early October.
- Beetles seem to prefer light-colored buildings and congregate on the south and west sides of a structure.
- They gain access to a building under siding, through unscreened vents, or other openings into wall voids, attics, and other sheltered places.

WHY CONSIDERED PESTS

- Adults can bite (though bites rarely break the skin).
- They release foul-smelling orange fluid that can stain indoor surfaces.
- Large numbers of beetles may wander about within a structure on warm days of winter.
- Exposure can cause serious allergic reactions.
- Adults also feed on ripening fruit (e.g., grapes, peaches) in late summer/early fall.

Crickets

These household invaders can produce the familiar, yet annoying chirping sound and can be seen hopping about a structure looking for shelter.

IDENTIFICATION

- Three common types of crickets found in structures are:
  - Field cricket (*Gryllus assimilis*) – ½ to ¾ inches (13 to 19 mm) long; dark brown to black body with long antennae and wings not covering abdomen (Figure 7.1 G); strongly attracted to light
  - Camel cricket (*Ceuthophilus species*) – ¾ inch (19 mm) long; tan with hump-backed body (Figure 7.1 H); wingless; not attracted to light
  - House cricket (*Acheta domesticus*) – ¾ inch (19 mm) long; light yellowish brown with 3 dark bands on thorax and long, pointed wings (Figure 7.1 I); strongly attracted to light

LIFE CYCLE

- They undergo gradual metamorphosis.
- Crickets overwinter as eggs in the soil.
- Nymphs hatch in late spring or early summer.
- One generation is produced per year in the upper Midwest.

NATURAL HABITAT, HOSTS

- Crickets are found in fields, pastures, along roadways, in grassy areas, and in rock piles or under logs.
- They feed on dead or dying insects and plant matter.

WHEN FOUND IN STRUCTURE

- Large population numbers near a structure result in accidental entrance into a structure.
- Attraction to light brings crickets close to structure.

WHY CONSIDERED PESTS

- Insect movement (e.g., walking, jumping) in structure and characteristic chirping sound can annoy occupants.
- Field crickets and house crickets will feed on fabrics causing damage, especially to fabrics with food or perspiration residues.
- Camel crickets will feed on paper products.

Ground Beetles

There are hundreds of species of ground beetles, all in the family Carabidae. Many are very common and often abundant.

IDENTIFICATION

- Size varies from ⅛ to 1 inch (3 to 25 mm) long.
- They are usually shiny black (Figure 7.1 J), though some are brown, and others have a metallic sheen or markings (Figure 7.1 K).
- Larvae are generally long and slender with distinct mandibles and strong legs.

LIFE CYCLE
- They go through complete metamorphosis.

NATURAL HABITAT, HOSTS
- Adults and larvae are fast-moving predators, feeding on other insects and related animals on and in the soil.

WHEN FOUND IN STRUCTURES
- Adults seeking food enter homes through loose-fitting windows and doors.
- Beetles are attracted to lights on or coming from a structure.
- They are often found near free moisture in a building.

WHY CONSIDERED PESTS
- Presence of a crawling insect in a structure is unacceptable to occupants.
- They often are misidentified as "waterbugs'" (cockroaches).

Clover Mite (*Bryobia praetiosa*)

Thousands of individuals are seen inside when these accidental invaders "move into" a building.

IDENTIFICATION
- They vary from 1/64 to 1/32 inch (0.4 to 0.8 mm) long.
- Oval body is bright to dark red with 4 pairs of legs, the front pair being very long and protruding forward at the head (Figure 7.1 L).

LIFE CYCLE
- Clover mites have a different progression of life stages: egg, larva, protonymph, deuteronymph, and adult.
- Clover mites overwinter as eggs outside.
- Two or more generations are produced per year in the upper Midwest.

NATURAL HABITAT, HOSTS
- They feed on outdoor plants including grasses, weeds (e.g., dandelion, shepherd's purse), ground-level fruits (e.g., strawberry), and herbaceous perennials (e.g., iris).

WHEN FOUND IN STRUCTURES
- They enter structures in early summer and again in fall.
- Population increases are often associated with lawn fertilization.
- Mites move into a structure accidentally or in response to negative environmental conditions (e.g., hot summer weather, removal of host plants).

WHY CONSIDERED PESTS
- The sheer number of red "dots" crawling on windowsills, walls, counters, and curtains in a structure is unsettling.
- They are easily crushed when touched, leaving a red streak in that area.

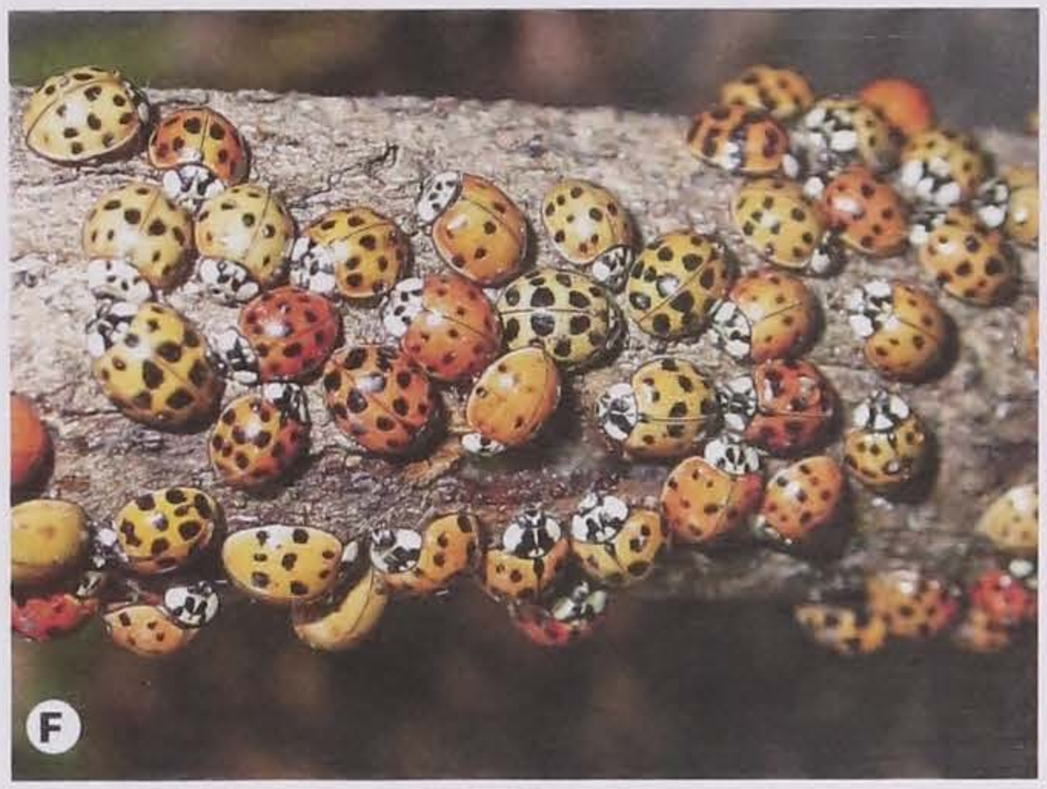


Figure 7.1. (A) Boxelder bug adult; (B) Boxelder bug adults and nymphs; (C) Boxelder bug aggregation; (D) Multicolored Asian lady beetle adult; (E) Multicolored Asian lady beetle larva; (F) Multicolored Asian lady beetle aggregation. Image credit: (A) Joseph Berger, Bugwood.org; (B) Jeffrey Hahn, University of Minnesota; (C) Erin Bauer, University of Nebraska-Lincoln; (D) Harvey Schmidt, http://bugsofmackie.blogspot.com; (E) Rick Cameron, http://racphoto.com; (F) Laura Jesse, Iowa State University Extension and Outreach

Figure 7.1. (G) Field cricket; (H) Camel cricket; (I) House cricket; (J) Black ground beetle; (K) Fiery hunter, a ground beetle; (L) Clover mite. Image credit: (G) TJ Walker, University of Florida; (H) www.stevenanz.com; (I) Joseph Berger, Bugwood.org; (J) Secundus, http://the-odd-draw.blogspot.com; (K) Allison Bockoven, http://6legs2many.files.wordpress.com; (L) Szarik, http://art-de-viant.deviantart.com

Pillbugs, Sowbugs

Bugs in name only, these animals are actually land-dwelling crustaceans (order Isopoda), related to crayfish and lobster. These are common outdoor arthropods that occasionally wander into houses.

IDENTIFICATION

- Size varies from ¼ to ½ inch (6 to 12 mm) long.
- Oval, domed, segmented body is dark gray to brown.
- They have seven pairs of legs with two pair of antennae.
- The top side of body has overlapping plates creating an appearance similar to a miniature armadillo (pillbug, Figure 7.2 A).
- Sowbugs have two tail-like appendages that project from the rear end of the body (Figure 7.2 B). Pillbugs do not have these appendages and can roll up into a tight ball when disturbed (Figure 7.2 C).

LIFE CYCLE

- Female lays eggs in a pouch underneath her body. When the eggs hatch, the small sowbugs live in this pouch for up to 2 months.
- Young sowbugs resemble adults, but smaller.
- Maturity requires about 1 year. Sowbugs can live up to 3 years.

NATURAL HABITAT, HOSTS

- They live in moist environments outside, feeding on fungi and decaying plant matter.
- They hide under objects during day to conserve moisture and are commonly found in mulch, compost, under boards, stones, flower pots and other items resting on damp ground around buildings.

WHEN FOUND IN STRUCTURES

- They may be found inside in spring, summer, and fall.
- They leave their natural habitats at night and crawl over sidewalks, patios, and foundations.
- They often invade crawl spaces, damp basements, and ground levels of buildings.

WHY CONSIDERED PESTS

- Presence within a structure is considered an annoyance to occupants.

Millipedes

Millipedes are slow-moving arthropods (class Diplopoda) occasionally found in basements.

IDENTIFICATION

- Millipedes are ½ to 1½ inches (13 to 38 mm) long.
- They are gray or dark brown, cylindrical, segmented, worm-like animals with two pairs of legs per body segment (Figure 7.2 D).
- They can curl or spiral their body when disturbed.

LIFE CYCLE
- Adult millipedes overwinter in the soil.
- Female lays eggs in clusters beneath the soil surface.
- Young gradually grow in size, adding segments and legs as they mature, which takes from 2 to 5 years.
- Individuals may live several years.

NATURAL HABITAT, HOSTS
- Millipedes eat decaying vegetation.
- They require high humidity to survive.
- Millipedes are found under pile of grass clippings, leaf litter, organic mulch, and similar items.
- They are common in farm reserve set-aside acreages.

WHEN FOUND IN STRUCTURES
- Millipedes enter a structure in response to drying of its habitat or soil moisture changes. They can enter in large numbers (Figure 7.2 E).

WHY CONSIDERED PESTS
- Their presence inside is considered a nuisance.
- Some people are disturbed by nocturnal movements of this arthropod.

House Centipede (*Scutigera coleoptrata*)

Fast-running, light-bodied household invaders catch the attention of building occupants.

IDENTIFICATION
- This centipede can be 1½ inches (38 mm) long.
- They have yellowish brown hues with three dark stripes running along the body with a lighter shading between them. They have 15 pairs of long, spindly legs, one per body segment, and large well developed multifaceted eyes (Figure 7.2 F).

LIFE CYCLE
- Eggs (over 100) are usually placed in damp locations.
- Larvae hatch with 4 pairs of legs, but more pairs are added as they mature.
- Centipedes require 2 to 3 years to mature and can live up to 6 years.

NATURAL HABITAT, HOSTS
- They can be found both indoors and outdoors in damp places such as cellars, closets, bathrooms, unexcavated areas under the house, and beneath the bark of firewood.
- Centipedes are frequently trapped in bathtubs and sinks.
- These arthropods are predators, feeding on small insects (e.g., silverfish, earwigs, crickets) and spiders (Figure 7.2 G).

WHEN FOUND IN STRUCTURES
- They are found throughout the year in homes; not a seasonal pest.

WHY CONSIDERED PESTS
- Presence of a fast-moving animal with long, spindly legs is unacceptable for most people.

European Earwig (*Forficula auricularia*)

These unusual insects were named from an old European superstition that they would enter the ears of a sleeping person, bore into their brain, and cause insanity.

IDENTIFICATION
- Adults are ⅝ inch (16 mm) long.
- They have a dark reddish brown, elongated body with short wings and a prominent pair of pincers at the posterior end. Pincers are used for self-defense and to capture prey (Figure 7.2 H).

LIFE CYCLE
- Females lay 30 to 55 eggs in a shallow hole in the ground.
- Females guard their eggs until they hatch.
- Earwigs undergo gradual metamorphosis.

NATURAL HABITAT, HOSTS
- Active during the night, these insects hide in cracks and crevices during the day.
- They are mainly scavengers eating pollen, fungal spores, vegetables, fruits, flowers, other plant parts, other insects, and household pantry items.
- They hide in mulch, balled or containerized plants, stones, rotting wood, tree cavities, and general debris (Figure 7.2 I).

WHEN FOUND IN STRUCTURES
- Man-assisted movement in bundles of newspaper, luggage, cut flowers, and vehicles readily occurs.
- They accidentally move into a building in search of food and moisture.
- Earwigs can be found in laundry, furniture, loaves of bread, and bedding.

WHY CONSIDERED PESTS
- The appearance of insect is frightening.
- They enter food facilities as well as pantries in homes.
- They emit a foul odor when disturbed.

Foreign Grain Beetle (*Ahasversus advena*)

Misnamed, this tiny household invader is not a stored product pest but is an opportunist looking for food in new construction.

IDENTIFICATION

- Beetle is 1/16 inch (1.5 mm) long.
- Adults are reddish brown, elongate, with a slight projection or knob on each front corner of the thorax (visible when magnified with hand lens) (Figure 7.2 J).
- Larvae are initially white and darken as they mature; 1/8 inch (3 mm) long.

LIFE CYCLE

- Beetles undergo complete metamorphosis.
- Females lay eggs in moist sawdust or another moldy food source.
- Larvae complete development within 20 days and construct a pupation chamber of food particles cemented together.
- Adults can live up to 300 days.

NATURAL HABITAT, HOSTS

- Beetles feed on molds and fungi, not on grain as their name implies.
- These pests are usually found in damp or spoiled grain and are common in grain storage facilities.

WHEN FOUND IN STRUCTURES

- Beetles invade structures in mid to late summer.
- Strong fliers, they are attracted to lights.
- They are often found in new homes feeding on molds growing on lumber exposed to moisture during the construction process.

WHY CONSIDERED PESTS

- Presence of large numbers of this tiny beetle in a structure causes occupants to confuse them with structure-damaging pests.

B

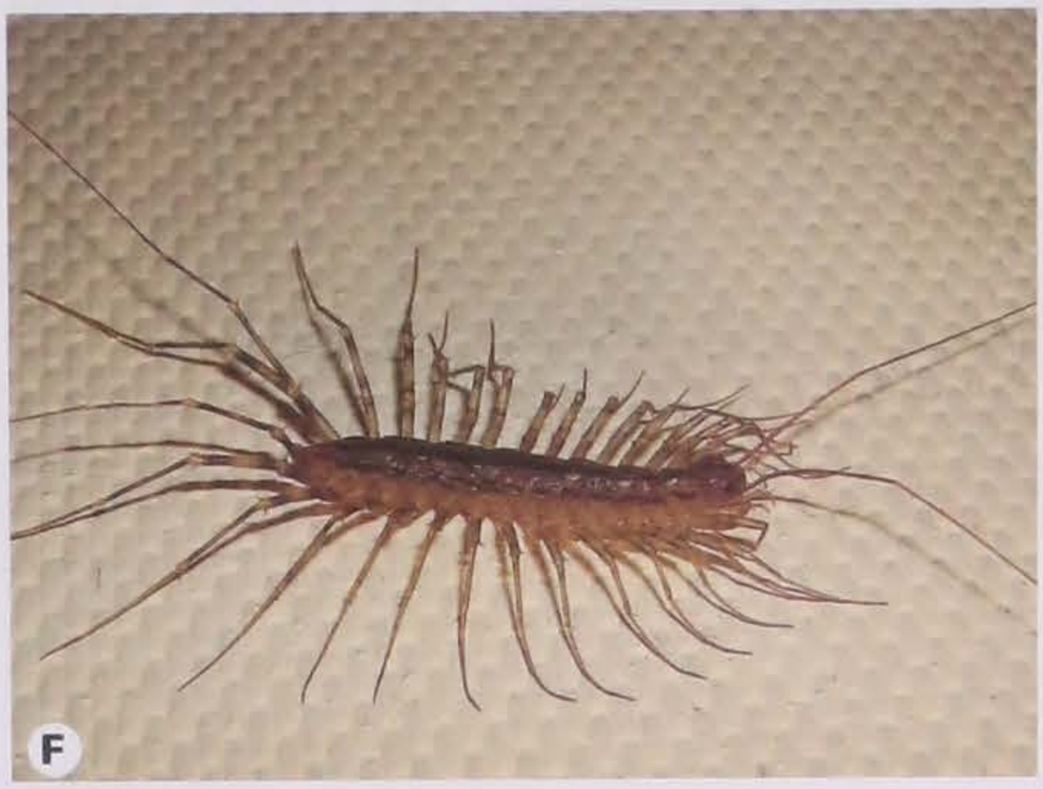


Figure 7.2. (A) Pillbug; (B) Sowbug (also called woodlouse); (C) Pillbug defensive position; (D) Type of millipede, note two legs per segment; (E) House millipede aggregation; (F) House centipede. Image credit: (A) Joseph Berger, Bugwood.org; (B) Andre Karwath, Wikipedia Commons; (C) Phillip, www.eastsidepatch.com/; (D) David Cappaert, Michigan State University, Bugwood.org; (E) M. Kraft, http://s74.beta.photobucket.com/user/rmshelley; (F) MrParts, http://mrparts.deviantart.com

Figure 7.2. (G) House centipede with prey; (H) European earwig; (I) Earwig aggregation; (J) Foreign grain beetle. Image credit: (G) Arthur V. Evans, www.arthurevans.wordpress.com; (H) David Cappaert, Michigan State University, Bugwood.org; (I) http://lexingtonalive.net/Insects/Earwigs.html; (J) Joseph Berger, Bugwood.org

Management of Accidental Invaders

Management of pests that accidentally wander into a building is somewhat dependent on the specific pest(s) present and how they entered the structure. Generally, nonchemical methods are the most successful in solving the problem.

Exclusion

Because these pests originate outdoors, exclusion techniques to prevent their entry are preferred.

- Seal cracks and gaps in foundations, siding, around chimneys, windows, doors, and any utility service (e.g., electric, gas, water) penetrating the outside building structure (Figure 7.3 A). Keep in mind that these pests can enter from ground level to the roofline.
- Use well maintained and tightly fitting windows, doors, and screens. Adjusting or replacing door brushes or rubber door threshold seals may be required (Figure 7.3 B).
- Use non-attractive lights (e.g., yellow incandescent or sodium vapor) for security needs (Figure 7.3 C). Close curtains or window shades to minimize interior lighting drawing arthropods near a structure.

Habitat Modification

Habitat modification is sometimes partially successful in managing accidental invaders by decreasing outdoor hiding and breeding places near a structure.

- Maintain a 2 to 3 foot (0.5 to 1.0 m) wide vegetation and mulch-free border around the foundation.
- Mow lawns and remove clippings in the building perimeter (Figure 7.3 D).
- Decrease lawn fertilizer in turfgrass near the building.
- Use less mulch in planting beds and rake piles of moist mulch, so they can dry out.
- Weed planting beds on a regular basis (Figure 7.3 E).
- Remove rotting wood and leaf litter from around entry doors.
- Prune back trees and shrubs away from the building.
- Move rock piles, firewood, equipment, and construction debris away from the building.
- Modify the downspouts and/or tile the site to drain water away from a structure if water accumulation is noted during inspection (Figure 7.3 F).

Ideas for modifying the habitat inside a structure include:

- Correct any moisture problems in ground level or basement areas.
- Decrease clutter and thoroughly clean rooms with exterior doors to minimize hiding places for incoming pests.
- Vacuum any pests encountered and dispose of the debris in a plastic garbage bag.
- Place sticky traps (used for cockroach monitoring) near exterior doors and windows, as these are effective in catching many structural invaders and will show where the pests are coming in.

Chemical Controls

There are some situations in which a pesticide application on the outside of the building is helpful in controlling accidental invaders. A similar treatment inside the building, however, is generally not recommended.

- Barrier treatment with a labeled, residual insecticide may need to be very large (4 to 10 feet; 1 to 3 m) to be effective. Repeat applications may be required during periods of heavy migration.
- Bait, granular, or microencapsulated formulations are sometimes more successful than residual sprays.
- Timing of pesticide applications should coincide with the beginning of migration events, which is late summer or early fall for most accidental invaders. Observing pest life stages in nearby trees or shrubs (e.g., boxelder bugs) justifies a spot insecticide treatment.
- Examples of active ingredients used in barrier treatments include boric acid, carbaryl, fipronil, indoxacarb, neonicotinoids (e.g., acetamiprid, clothianidin), and pyrethroids (e.g., beta-cyfluthrin, bifenthrin, deltamethrin, esfenvalerate, lambda cyhalothrin, permethrin).
- Pyrethroid labels have special requirements for outside applications to reduce drift (wind-carried contamination) and runoff (storm water-carried contamination). Some of these requirements include:
  - Treatments to impervious surfaces (e.g., sidewalks, driveways, porches, and patios) are limited to spot and crack-and-crevice applications.
  - Application bands up to 1 inch (2.5 cm) may be applied to cracks or other potential pest entry points;
  - Applications are permitted to the exterior of buildings where the treated surfaces are underneath eaves, soffits, windows, or doors that are protected by coverings, overhangs, awnings, or other structures protected from rainfall.
  - Applications are limited to crack-and-crevice or building foundations up to a height of 3 feet (1 m) only if the exterior of a building is not protected from rainfall.
  - Treatments may be made using a coarse, low-pressure spray to portions of surfaces that are directly above bare soil, lawn, mulch or other vegetation.
  - Other limitations and permitted uses can be found on product labels.

Figure 7.3. (A) Sealing cracks and crevices; (B) Adjusting door sweeps; (C) Use of yellow/sodium vapor lighting; (D) Well-mown lawn with no foundation planting or clutter; (E) Weeding flower gardens near structures; (F) Downspout extension. Image credit: (A) Katharine Swan, www.wisegeek.org; (B) www.ednewscolorado.org/; (C) http://ledelco.wordpress.com/; (D) http://grizzlybearlawncare.com; (E) http://wintonfamiliesmore.blogspot.com/; (F) GardeningGrrl, http://gardeninggrrl.wordpress.com

Learning Objectives

After studying this chapter, you should be able to

- Define: ectoparasite, nit, pediculosis, canine detection
- List three blood-sucking insects found in/around a structure
- Differentiate three common ticks
- Discuss the cat flea life cycle and primary hosts
- Identify three signs of a bed bug infestation at a site
- State the activity period(s) of bed bugs
- Name ways bed bugs can move unassisted or assisted by humans
- Differentiate three lice species associated with humans
- Explain the disease implications of: ticks; fleas; lice
- Associate the available monitoring tool(s) for blood-feeding pests
- State the key issues in designing a management program for: ticks, fleas, bed bugs, lice
- Explain why delusional infestation is encountered by a pest manager during business activities

Chapter 8
Blood-feeding Pests

Overview

A few species of arthropods feed on the blood of specific animal hosts, with some intentionally or accidentally feeding on humans. These pests are called **ectoparasites** when they feed externally, taking blood from their hosts. In addition to the irritation of their bites, some of these pests may transmit serious disease-producing organisms.

Pest management approaches will be discussed for each type of pest because control methods will vary. It is important to note, however, that you can treat the environment (e.g., structure and its perimeter) but you cannot treat pets, other animals, or humans.

Ticks

Ticks are small arthropods, more closely related to spiders and mites than to insects. Several ticks are parasites of animals, with humans serving as an **alternate host**. Their life cycle includes the egg stage, a six-legged larval stage, the nymph stage, and the adult stage; the nymphs and adults have eight legs. All life stages (after egg stage) suck blood through a specialized mouthpart called a **hypostome**.

Ticks find a host by climbing vegetation and reaching out from this perch to grab onto a passing host (Figure 8.1). These arthropods locate hosts by the carbon dioxide, host odors, and/or heat coming from the host. After feeding, ticks drop to the ground for their next life function (molting or laying eggs).

Ticks are most commonly found in woodland, mixed shrub, and overgrown areas. They are especially common along overgrown borders and paths, since passing hosts frequent these areas. Ticks are seldom found in open areas of mowed yards.

Ticks generally resemble the shape of watermelon seeds. On the back of most common ticks is a shield called a **scutum**. This structure is often colored and textured and can help with species identification. The scutum covers the back of male ticks, but only covers the anterior portion of the back of females.

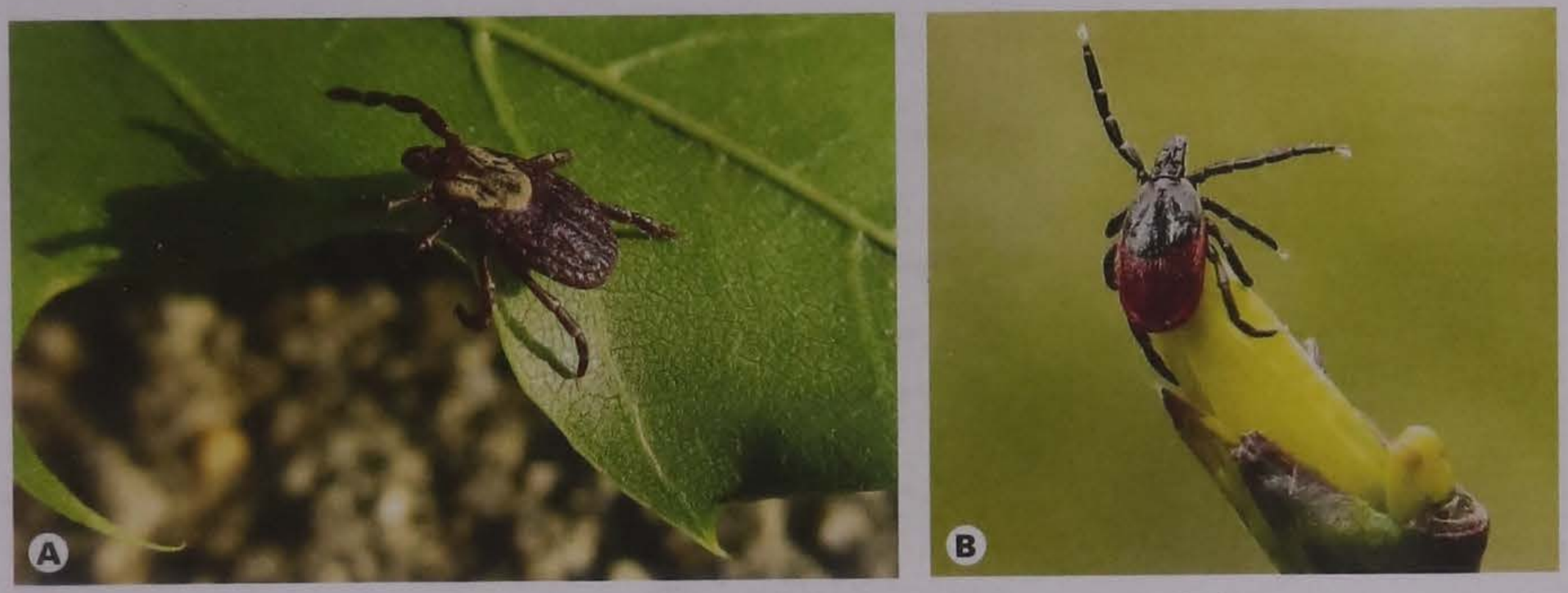


Figure 8.1. (A) American dog tick awaiting host; (B) Deer tick awaiting host. Image credit: (A) Scott, http://littlecrumcreek.wordpress.com; (B) www.blog.texaspestexterminator.com

Deer Tick (*Ixodes scapularis*)

Also called the bear tick or blacklegged tick.

IDENTIFICATION

- Unfed adult female is ⅛ inch (3 mm) long; larvae are 1/32 inch (0.8 mm) long (described as a moving freckle); nymphs are 1/16 inch (1.6 mm) long (size of a poppy seed). Fully fed females (called engorged) are much larger (greater than ½ inch; 12.7 mm).
- This tick species has a flattened, orange-brown body with a dark brown scutum, mouthparts, and legs (Figure 8.2 A).

LIFE CYCLE AND HOSTS (Figure 8.2 B)

- Larvae hatch in late June or early July.
  - Hosts are white-footed mice, other small mammals, and birds.
  - Once fed, the larva drops to the ground, molts to the nymphal stage, and overwinters in a protected site.
- Nymphs are active from April to August.
  - Hosts include dogs, birds, horses, cattle, or humans.
  - After feeding, the nymph drops to the ground and molts into an adult in the fall.
- Adults find a host (e.g., white-tailed deer), feed, mate, and drop to the ground where the female lays eggs and dies.

IMPORTANT CONSIDERATIONS

- This species is an important vector of the bacterium (*Borrelia burgdorferi*) that causes Lyme disease.
  - Larvae acquire the pathogen from feeding on infected rodents.
  - Nymphs are the most important vector because they are small, feed on larger mammals, feed for a short period, and may have fed on an infected host the previous year.

Brown Dog Tick (*Rhipicephalus sanguineus*)

This is the most common tick found indoors. In fact, the brown dog tick does not survive well outdoors because it prefers warm, dry areas in which to live.

IDENTIFICATION

- Unfed adults are ⅛ inch (3 mm) long; an engorged female is ½ inch (13 mm) long (Figure 8.2 C, D).
- Adults are reddish brown, "soft ticks" (lack a scutum) and have no distinct markings. The engorged females are bulbous and gray or gray blue.

LIFE CYCLE AND HOSTS

- Female lays 1,000 to 3,000 eggs in cracks and crevices; these can be laid anywhere in a structure from the baseboards to the ceiling. Eggs may hatch over a period of five months.
- Primary host is the dog for all feeding stages. The preferred feeding sites are along the back, between toes, and in ears.
- Ticks can survive for more than six months in an unfed state hidden in cracks and crevices.
- Dogs do not get these ticks from other dogs, but from passing through a tick-infested area.

IMPORTANT CONSIDERATIONS

- The large numbers of hiding places in a structure make this tick very difficult to control.
- Brown dog ticks very rarely feed on humans.
- This tick is not a known disease vector.

American Dog Tick (*Dermacentor variabilis*)

This tick species is native to North America and is capable of vectoring diseases. It is also known as the wood tick.

IDENTIFICATION

- Unengorged female is 3/16 inch (5 mm); male is ⅛ inch (3 mm) long (Figure 8.2 E).
- Ticks are flattened and brown with whitish markings on the top of the body.

LIFE CYCLE AND HOSTS

- Female (Figure 8.2 F) lays 4,000 to 6,000 eggs on the ground in wooded areas.
- Preferred host is dogs, but this species will feed on wild rodents, rabbits, cattle, horses, and humans. Most common feedings sites are around the head and ears.
- American dog ticks cannot complete their life cycle inside a structure.
- Adult ticks are active from late spring through the summer.

IMPORTANT CONSIDERATIONS

- This tick species is principal vector of Rocky Mountain spotted fever; it can also transmit tularemia and cause tick paralysis.
- Campers, hikers, and hunters frequently encounter this tick when walking through overgrown areas, woods, fields, and parks.

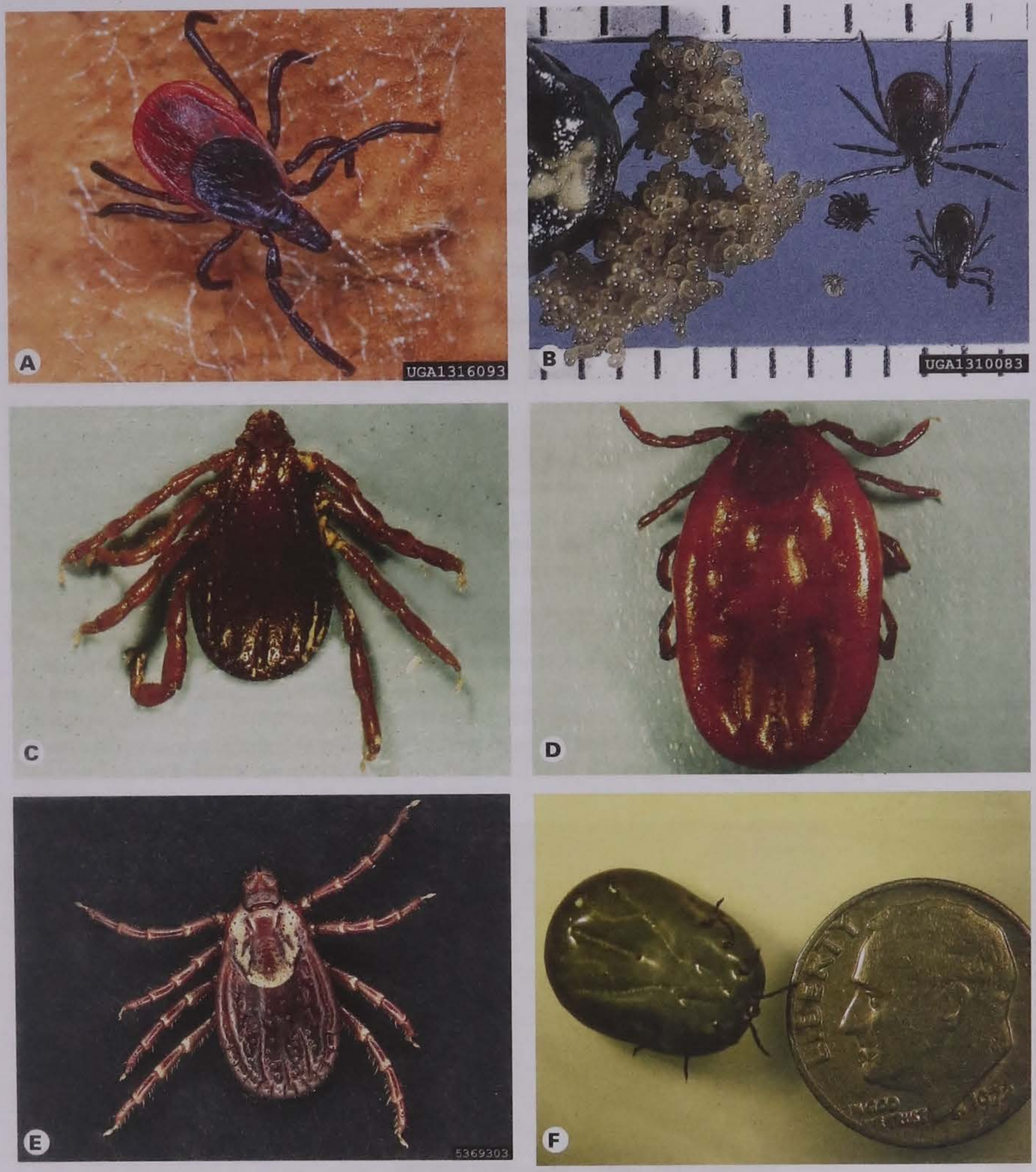


Figure 8.2. (A) Deer tick; (B) Deer tick life cycle (left to right – engorged female, eggs, 2 nymph stages, adults); (C) Brown dog tick, male; (D) Brown dog tick, engorged female; (E) American dog tick; (F) Engorged American dog tick. Image credit: (A) Scott Bauer, USDA Agricultural Research Service, Bugwood.org; (B) Jim Occi, BugPics, Bugwood.org; (C and D) Michael Dryden, College of Veterinary Medicine, Kansas State University; (E) Susan Ellis, USDA APHIS PPQ, Bugwood.org; (F) www.allencountyhealth.com

Tick Management

Integrating the following management methods in a short time period will have the greatest impact on controlling tick populations.

Indoors

Tick control indoors is limited to brown dog tick infestations, since the American dog tick and the deer tick cannot complete their life cycles indoors.

Management of the brown dog tick in homes requires frequent inspection and removal of ticks from pets. Pet bedding should be laundered, and rugs, floors, and furniture should be routinely vacuumed, especially along baseboards and behind furniture. Insecticide treatment should focus on cracks and crevices along baseboards and molding, around door and window frames, underneath furniture, beneath the edges of carpeting, behind loose wallpaper, and in similar hiding areas. Pay special attention to where the dog spends time. Insecticide active ingredients include carbaryl, bendiocarb, and permethrin. The homeowner should be reminded to keep children and pets off treated surfaces until sprays have dried. Because the eggs and immatures may take several weeks to hatch or molt, retreatment may be necessary to eliminate all brown dog ticks in a structure.

Outdoors

Ticks are sometimes a problem in yards, especially when pets are kept outdoors. Ticks also can be a serious problem in parks, camps, picnic sites, and other recreational areas. One method of determining if ticks are present is to drag a 3 feet x 3 feet (1 m x 1 m) white flannel cloth through suspected areas (Figure 8.3). Ticks will attach and be visible against a white background.

Figure 8.3. Use of white sheets and clothing to detect tick population size. Image credit: http://aswcsu.blogspot.com/

Tick populations can be reduced in these areas by mowing lawns and trimming other vegetation, thus creating a less favorable habitat for ticks and their wild hosts. Discourage wildlife by keeping lids on garbage cans and stopping the practice of feeding wild birds. Dropped bird seed encourages mice to live nearby. In some cases, wild birds may carry ticks to a new location.

Repellents are an important element in protecting people in the area. These chemicals should be applied to clothing and areas of the body specified on the product label. Educate people that they should tuck shirt and pant legs in when walking in tick habitat. In addition, clothing should be checked after trips outdoors through these areas.

Insecticide sprays are most effective when directed into areas where ticks and their animal hosts are likely to frequent. Pay particular attention to border regions between wooded and grassy areas, around ornamental plantings, along footpaths, and around pet pens and runs. A single application in early to mid-May is often all that is required, although re-treatment may be necessary at the interval specified on the product label. Insecticide active ingredients include carbaryl, permethrin, and cyfluthrin.

The ground and vegetation up to a height of 3 feet (1 m) should be thoroughly wetted with the insecticide mixture. Children and pets should be kept off treated areas until the vegetation is completely dry. Treating the entire lawn is not recommended since ticks avoid direct sunlight and normally do not infest areas that are well maintained.

Fleas

Cat Flea (*Ctenocephalides felis*)

Although there are several species of fleas known to exist, the cat flea is the most commonly encountered in/around structures. Their vertically flattened body allows them to move between hairs of an animal's coat. Fleas are well-known for their ability to jump 6 inches (15 cm) or more.

IDENTIFICATION

- Adults are 1/16 to 1/8 inch (1.5 to 3 mm); larvae are 1/6 inch (4 mm) long.
- Adults are reddish brown to black and flattened from side to side. Wingless, they have 3 pairs of jumping legs and small eyes (Figure 8.4 A).
- Larvae are whitish to transparent with a small, brown head and are legless (Figure 8.4 B).

LIFE CYCLE, HOSTS

- Fleas undergo complete metamorphosis (Figure 8.4 C)
- Adult male and female fleas live and breed on the host animal and feed on its blood. Hosts include cats, dogs, and rodents; humans are an **incidental host**.
- Females lay 200 to 400 eggs on the host; eggs fall off and larvae develop in pet-resting areas.
- Larvae remain hidden deep in carpet fibers, beneath furniture cushions, in pet bedding, in dog houses, under porches, and other protected sites.
- Larvae feed on organic debris, especially dried blood in adult feces (called flea dirt), which accumulates along with the eggs in animal resting and bedding areas.
- Larval stage length is from one week to several months, depending on environmental conditions.
- Loose, white silken cocoon cases enclose developing pupae; this stage lasts 7 to 10 days.
- The pupa then transforms into an immobile form called the **preadult**; it may remain in the silken cocoon for months until stimulated to emerge by favorable conditions of vibrations from hosts, increased carbon dioxide levels, or a sufficient number of warm, humid days.

- Adult fleas are ready to feed as soon as they leave the cocoon.
- Life cycle can take as few as 12 days or as long as 140 days, depending on temperature, humidity, and host availability.

IMPORTANT CONSIDERATIONS:

- Fleas feed by biting and sucking blood. They inject saliva that results in site irritation and subsequent scratching by the host.
- Fleas will bite adult humans on their ankles and children in several places as they crawl around or play on the floor.
- Some individuals are hypersensitive to flea bites, causing itching and irritation.
- Fleas can transmit serious diseases to humans, most notably plague and flea-borne typhus, which were initially acquired by feeding on infected rodents (e.g., Norway rat).
- Fleas can transmit tapeworms from pets to people.
- Severe problems with fleas can occur when a person moves into a house that previously had pets or a rat infestation.
- Severe cat flea infestations can cause sufficient blood loss to result in poor animal health (Figure 8.4 D).

Flea Management

Managing fleas requires an integrated approach. The pets and the environment must be dealt with at the same time to best remedy the situation.

Inspection

Flea management begins with an inspection of the environment and the identification of the insect. Ear mites (controlled solely by a veterinarian) can cause symptoms similar to a flea infestation. If the customer's pet is allowed to roam in woodland sites, it is possible for the pet to pick up fleas from wildlife. Check to see the specific identity of the insect captured, as most of the wildlife fleas cannot develop on dogs or cats.

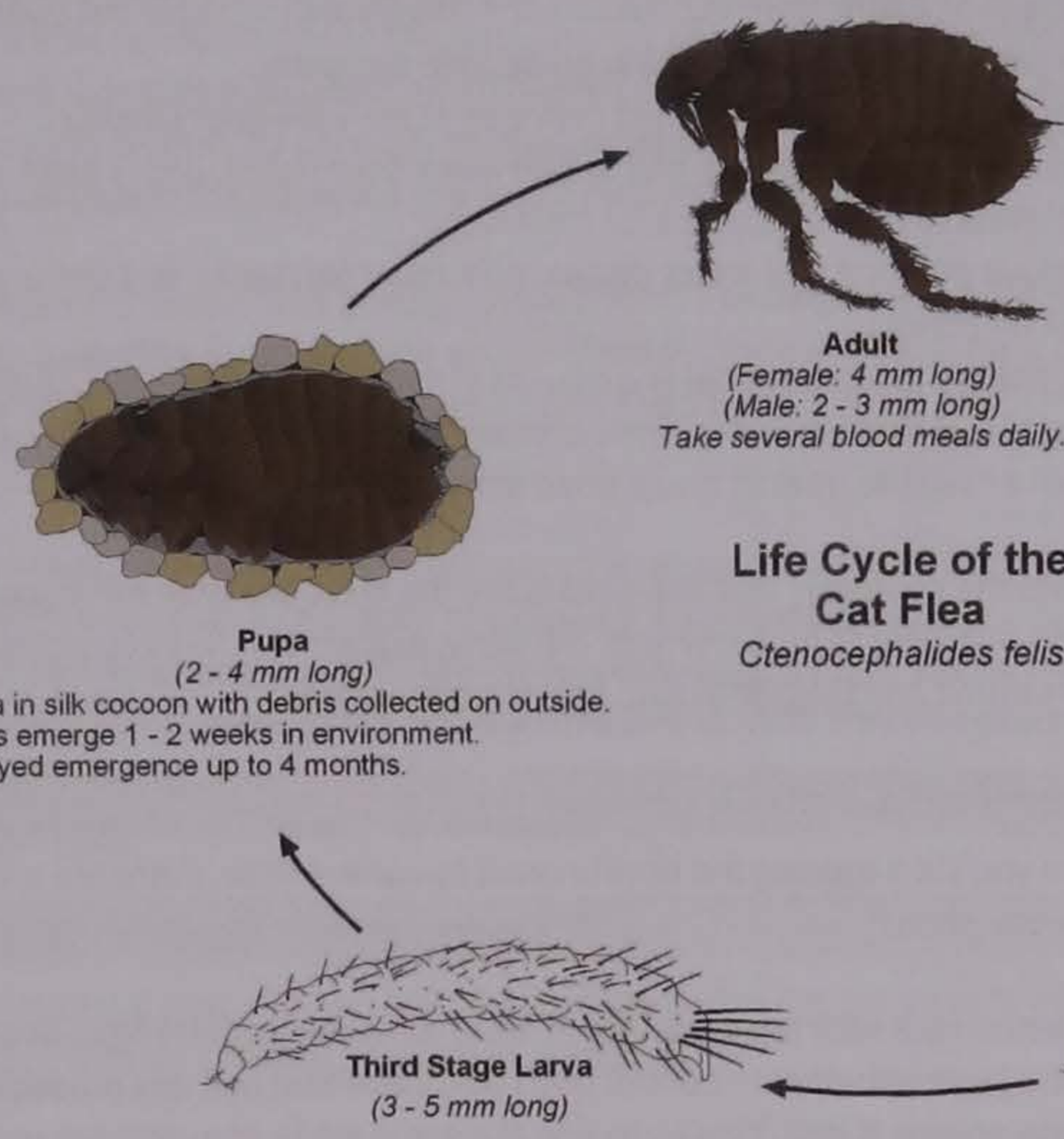
Inspect the premises. Look for areas with flea dirt and high numbers of fleas. Wear white socks and take off your shoes while inside; walk around each room for two minutes. Fleas landing on your socks will be visible and allow you to make an estimate of the flea population size.

Check crawlspaces, kennels, under furniture, in closets, pet paths, and pet resting areas. Ask the customer about the pets and learn their favorite resting areas and where fleas were seen. Adult fleas are attracted to disposable glue boards illuminated by a bright light; place this close to the floor and turn off all other lights. Raking carpets will also stimulate adult flea activity.

You may sometimes find fleas in a home that has no pets; this may be a result of the pets owned by the previous occupant. It is also possible for fleas to be present, but these are not feeding on pets in the home. Check the chimney, attic, and crawlspace to see if wild animals (e.g., raccoons) are living there. Remove any animals that are found as the first step in solving the flea problem.

A

B



C

D

Figure 8.4. (A) Cat flea adult; (B) Cat flea larva;
(C) Cat flea life cycle; (D) Flea-infested dog.
Image credit: (A) http://caninegoodcitizen.wordpress.com;
(B and E) www.warrenphotographic.co.uk/;
(C) http://fleasinhouse.co; (D) www.animalcaresociety.org/

Customer Involvement

Provide your clients with a flea factsheet and a list of tasks they will be responsible for to solve the problem. Be certain to explain that the flea inside the pupal case cannot be killed. Within three weeks, fleas will emerge from the pupal cases and will be controlled if you have applied a residual insecticide.

In addition to treating the pet, the customer can follow several tactics to help get rid of the fleas.

- Launder intact (still usable) pet bedding and throw rugs.
- Vacuum carpeting in each room thoroughly and daily. Beater bars will improve removal of larvae and eggs from the carpets.
- Vacuum furniture, the pet bed, and wood floors using proper attachments.
- Dispose of debris from vacuuming and frayed/old/unusable pet bedding in a plastic trash bag, placed in an outside dumpster.
- Seal or repair floor cracks and crevices at the wall-floor junction.
- Remove all toys, clothing, and stored items from floors, under beds, and in closets to provide access for treatment.
- Remove pet food and water dishes, and cover fish tanks and disconnect their air pumps.
- Secure the pet in a kennel in a non-treatment area or have the veterinarian treat the animal while the home is being treated. Pets and people can be given access to treated areas once sprays have dried.

Educate the customer that flea collars are the least effective treatment method available to homeowners. Similarly, explain that fleas do not react to ultrasound and that ultrasonic devices are useless.

Chemical Control

Before you start treating the environment to control fleas, there are a few things you should do:

- Communicate with the customer to learn what pesticide(s) have been used on the lawn (whether to control lawn pests or fleas) and any product used on the animal. If insecticides having the same mode of action are used on the pet, in the home, and in the yard, pets may suffer overexposure.
- Make sure the pesticide label allows you to make the intended application. Fleas can live on the pet as well as in the home, kennel, and lawn.
- Make sure the structure is ventilated following treatment and the carpets are dry before allowing pets or children on them. Power fans or dehumidifiers may be helpful during very humid weather when carpets dry slowly.

Surface and crack-and-crevice sprays are routinely applied for flea control. Both broadcast and spot treatments are useful in killing larval and adult fleas that come in contact with the sprays. Thorough application is essential to reach concealed areas (e.g., under furniture). Apply sprays as an even, fine spray under low pressure. Hardwood and tile floors should not be treated, but should be vacuumed and mopped.

Several effective insecticides are available for adult flea control. Active ingredients include 2-phenylethyl propionate, pyrethrins with piperonyl butoxide and several pyrethroids (e.g., bioallethrin, bifenthrin, cyfluthrin, cyhalothrin, cypermethrin, deltamethrin, esfenvalerate, imiprothrin, permethrin, phenothrin, prallethrin, and tetramethrin).

As a tank mix with conventional insecticides, IGRs are very effective at long-term reduction of flea populations. These chemicals work by interrupting normal development from the larval to adult stages. IGRs have long residues (up to 120 days), but are nontoxic to people and pets, thus work well in a residential IPM program. An example of two IGR active ingredients registered for use in Iowa are methoprene and pyriproxyfen.

Be aware that some pesticides may stain upholstery, carpets, or other finished surfaces. Dyes used in the manufacture of some red fabrics and carpets will turn yellow or green when treated with acidic pesticides. Select a non-staining product by carefully reading prospective product labels. It is wise to always test the pesticide in a small, hidden area first.

Total release aerosols ("flea bombs") have limited use because they do not penetrate areas in a structure well and are hard to place directly where they are needed. Also, they can cause explosions if you fail to turn off pilot lights before making the application.

Outdoor areas, where inspection indicates the presence of fleas, should be treated with a residual formulation of a labeled insecticide. Be especially aware of perimeter areas around the home, paths used by animals, kennels, and sleeping areas under decks and porches where fleas may be developing.

Bed Bugs

Bed Bug (*Cimex lectularius*)

Once a historical pest, the bed bug has become one of the top insects that PMPs deal with on a weekly, if not daily, basis.

IDENTIFICATION

- Bed bugs are 3/16 to 1/4 inch (5 to 6 mm) long.
- They are reddish brown with an oval, flattened body; minute, golden hairs cover most of body. The insect is wingless with 3 pairs of walking legs and a 2-segmented antennae (Figure 8.5 A).

LIFE HISTORY, HOSTS

- Bed bugs undergo gradual metamorphosis.
- Females lay 5 eggs/day in cracks or cement them to rough surfaces. A female can produce 500 eggs in her lifetime.
- Each nymph stage requires a blood meal to molt (Figure 8.5 B); adults also feed on blood.
- Life cycle can be completed within 20 days (regular blood meals, constant warm temperature) (Figure 8.5C).

- Primary host is humans, but will feed on pets or small rodents.
- Related species may use humans as an alternate host:
  - Bat bug—*Cimex adjunctus*
  - Swallow bug—*Oeciacus vicarius*
  - Purple martin bug—*Hesperocimex coloradensis*
- Flattened bodies allow them to hide in cracks/crevices near place where host sleeps (e.g., bed, couch, recliner); usually within 15 feet (4.5 m) from host, but can crawl 50+ feet (15.2 m) to obtain a meal (Figure 8.6 A-D).
- Bed bugs are usually active at night, but will feed in daytime if host is present and inactive.
- Bed bugs can survive extended periods (up to 5 months) without a blood meal.

IMPORTANT CONSIDERATIONS

- Bed bugs are not known to transmit any diseases.
- These human ectoparasites penetrate host skin with an elongated, sharp beak.
- Bite responses range from no reaction to red welts to intense itching (Figures 8.6 E, F).
- Possible negative outcomes include secondary infection, discomfort, anxiety, sleeplessness, embarrassment, loss of work, and financial burden.
- Masters at hitchhiking, they can hitch a ride in backpacks, suitcases, brief cases, purses, furniture, clothing, books, laundry, boxes, and wheel chairs.
- Bed bugs also will crawl along pipes, electrical wires, along edges of room, and under doors to gain access to hosts.

Bed Bug Management

IPM methods are very important in controlling bed bug infestations.

Prevention

Customers should be told the three basic ways to prevent getting bed bugs:

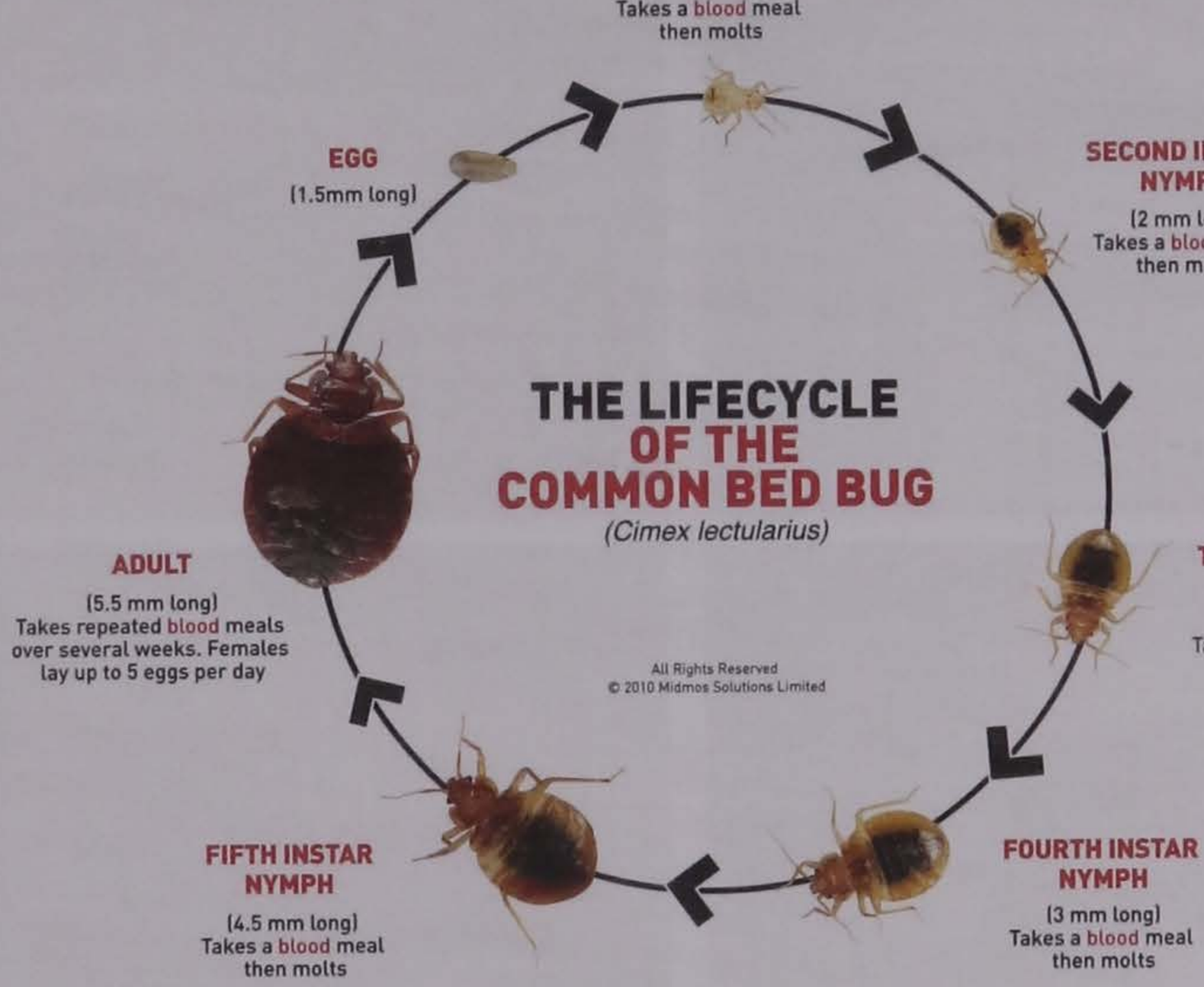
- Inspect hotel/motel rooms before settling in.
- Carefully check luggage after a trip, paying attention to seams and crevices; launder all clothing.
- Avoid acquiring used furniture at garage sales, online, or off the curb.

Inspection

When confronted with a bed bug complaint, begin with a thorough inspection of the structure. Ask occupants what and where they think the problem is. You should pay attention to odors, as an infested apartment or bedroom may have a characteristic "obnoxious sweet" smell, sometimes likened to the odor of fresh red raspberries.

A

B



C

Figure 8.5. (A) Bed bug adults, female (left) and male (right); (B) Nymphal bed bug feeding; (C) Bed bug life cycle. Image credit: (A) Richard Book, http://medent.usyd.edu.au; (B) Piotr Naskrecki, Wikipedia Creative Commons; (C) Midmos Solutions Limited

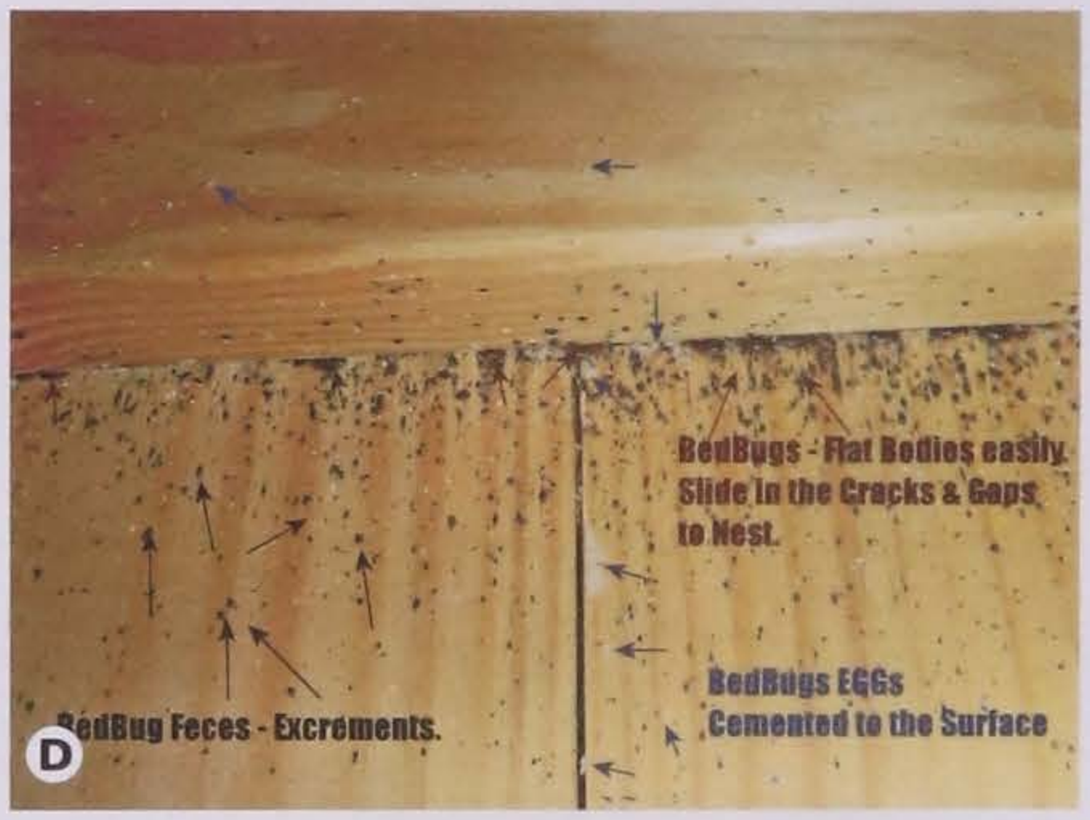


Figure 8.6. (A) Bed bugs on mattress; (B) Close up of bed bugs on mattress; (C) Bed bugs on boxsprings; (D) Signs of bed bug infestation on floor under host bed; (E) Bed bug feeding aggregation on human shoulder; (F) Response one day after bed bugs were fed on human forearm. Image credit: (A) http://cmr.asm.org; (B) http://spiderspray.com/blog/; (C) Laura Jesse, Iowa State University Extension and Outreach; (D) www.qpm.ca/; (E) http://thebedbugassassin.com; (F) Lou Sorkin, http://firstaid.about.com/

Beginning with the area(s) where people sleep, inspect all crevices where bed bugs could hide. Signs of an infestation include live bed bugs, dead bed bugs, shed skins, fecal/blood smears, and tiny white eggs. Places to check include:

- Under the bottoms of mattresses, in the coils or bed springs, on the bed frame.
- Along edges of and in recessed screw holes of bedroom furniture (e.g., night stand, end table, headboards, dressers).
- Behind loosened wallpaper, calendars, or pictures.
- Inside pleats of draperies, electrical switch plate covers, upholstered furniture, and electronics (e.g., alarm clocks, radios).
- In clothing, books, boxes, and other items left on the floor or under the bed.

Detection Methods

Monitoring devices are designed to confirm the presence of bed bugs. There are two types of commercially available traps. One type is a passive monitor that a bed bug crosses while seeking shelter. Passive monitoring is most effective in a room where people regularly sleep. This type of monitoring includes barrier tapes on bed legs, interceptor devices beneath bed legs (Figure 8.7 A), or a sticky surface sandwiched between small cardboard or plastic pieces (Figure 8.7 B). A second type is called an active monitor because there are host volatiles, carbon dioxide, and/or heat to attract bed bugs to the device. These monitors are reported to be most effective in vacant rooms. The efficiency and safety of both types of traps is still uncertain, as these are new tools for combating bed bugs.

Use of dogs (**canine detection**) to locate bed bugs is another method being employed by PMPs (Figure 8.7 C). These highly trained dogs are specific to this pest. Dog handlers must not mix or apply pesticides or other chemicals because these would interfere with the dog's performance. Like monitoring, the effectiveness of this method is still uncertain.

Chemical Control

A properly labeled insecticide may be applied to bed bugs and their harborages. Take extra care when treating mattresses and box springs. Apply the pesticide lightly in seams, folds, and buttons (Figure 8.7 F). Allow the treatment time to dry thoroughly before allowing use. Do not treat beds used by infants, elderly, or sick people. Do not treat linens; instead wash them in hot, soapy water and heat dry.

Apply the insecticide to cracks and crevices, under loose baseboards, around window and door casings, and at the floor-wall and ceiling-wall junctures. Furniture may also be infested and may need to be treated with a registered insecticide. Do not use broadcast or fog treatments, as these have limited effectiveness.

There are several insecticide active ingredients registered to control bed bugs including: 2-phenylethyl propionate; DDVP; diatomaceous earth; silicon dioxide; neonicotinoids (e.g., acetamiprid, imidacloprid, dinotefuran); pyrethrin + piperonyl butoxide or MGK 264; pyrethroids (bifenthrin, bioallethrin, cyfluthrin, cypermethrin, cyphenothrin, deltamethrin, esfenvalerate, permethrin, phenothrin); and IGRs hydroprene and methoprene.

Other Treatments

Encasements are zippered enclosures that cover bed components (e.g., mattress, box springs, upholstered furniture) (Figure 8.7 D). They trap bed bugs inside (bugs cannot feed through this fabric). Their light color provides the contrast needed to spot bed bugs during re-infestations. You can suggest that the client purchase these to eliminate the need to discard this furniture.

Thorough vacuuming can be used in conjunction with other management strategies, but will not eliminate an infestation (Figure 8.7 E). To prevent bed bugs from getting into the vacuum cleaner, insert a knee-high nylon stocking in the end of the vacuum hose, then insert the crack and crevice attachment. Vacuum furniture, bed components, edges of flooring, and other possible harborage sites. When you are finished, immediately remove the stocking, tie a knot in the top, and place in a sealed plastic bag for disposal in an outside trash container.

Steam, when properly and directly applied, kills all life stages of bed bugs. This treatment can be used on mattresses, upholstered furniture, and along edges of carpets and rugs. The steam cleaner nozzle should be moved slowly (20 seconds per linear foot) to maximize depth and time of exposure. Dry steam or low-vapor steamers are preferred because they leave behind less moisture.

Heat treatment of the entire house or apartment also has the advantage of killing all life stages. Whole unit heat treatments use a series of heat-generating units and fans to circulate super-heated air. If you are dealing with a multiple-unit dwelling, careful inspections of adjacent units must be done to prevent bed bugs from re-infesting the heat-treated unit following the procedure.

The use of cold treatments is also being investigated as a method to kill bed bugs. Cryonite® is a rapid-freeze technology that uses carbon dioxide "snow" to treat cracks and crevices, in the same fashion as steam treatments.

Lice

Lice are ectoparasites of warm-blooded animals and people. Although there are several types of lice that feed on various animals, there are only three that must have a human host.

Lice undergo gradual metamorphosis. A blood meal is required for nymphs to proceed to the next immature stage and to the adult stage; adults also feed exclusively on human blood. Eggs are referred to as **nits** (Figure 8.8 A) once they have hatched. Eggs and nits are often mistaken as dandruff or shampoo residues to the untrained eye.

B

Figure 8.7. (A) Climb up bed bug monitor; (B) Sticky type of bed bug monitor; (C) Dog used for bed bug detection; (D) Mattress enclosure; (E) Vacuuming as an integrated control method; (F) Insecticide treatment of mattress and box springs. Image credit: (A) Erin Bauer, University of Nebraska-Lincoln; (B) www.gardexinc.com; (C) http://illinoisbedbugdog.com/blog; (D) http://greatfurnituredeal.com/; (E) www.ustermite.com; (F) Laura Jesse, Iowa State University Extension and Outreach

When lice feed, they inject saliva into the host, causing itching and discomfort. Scratching areas can intensify the itching. Host distress also occurs from lice crawling on the body. **Pediculosis** is a skin condition resulting from continuous and severe infestation of lice (Figure 8.8 B). Scarred, hardened, oozing, and pigmented skin results from continuous scratching of louse bites.

Head Louse (*Pediculus humanus capitis*)

IDENTIFICATION

- Adults are 1/10 to 1/8 inch (2 to 3 mm) long.
- Head lice are tan to grayish white in color with an elongate body.
- Lice have 3 pair of legs, each bearing a claw at the end of the leg (Figure 8.8 C).

LIFE HISTORY, HOSTS

- Females cement their eggs to individual hair shafts approximately ½ inch (13 mm) from scalp; eggs do not hatch if removed from a host.
- Average lifespan is 32 days.
- The head louse lives and feeds on the head of its human host; preferred sites include nape of the neck and the area behind the ears.
- Head lice will infest scalp hair, eyebrows, and eyelashes.
- They become dehydrated quickly if they fall off their host.
- They move quickly and avoid light, making them difficult to see.

IMPORTANT CONSIDERATIONS

- Head lice are not known to vector any human diseases.
- They are spread primarily by head-to-head contact.

Body Louse (*Pediculus humanus humanus*)

IDENTIFICATION

- Adults are 1/10 to 1/8 inch (2 to 3 mm) long.
- The elongated body is tan to grayish white.
- They have 3 pair of legs each bearing a claw at the end of the leg.

LIFE CYCLE, HOSTS

- Life span is approximately 30 days.
- This species is also called the clothing louse. It is most commonly found on host clothing and comes in contact with skin to feed.
- Females attach their eggs to fibers of clothing, especially along the seams of the inside surface of clothing.
- Body lice cannot survive off of the host longer than 48 hours.

IMPORTANT CONSIDERATIONS

- The body louse vectors several human diseases, including epidemic typhus, trench fever, and louse-borne typhus (epidemic relapsing fever).
- Lice are generally associated with destitute humans who regularly sleep in their clothes, older incapacitated individuals, or groups of people living in close association under poor sanitation.
- They are transmitted by contaminated clothing or shared bedding.

Pubic Louse (*Pthiris pubis*)

IDENTIFICATION

- Adults are 1/16 inch (1.5 mm) long.
- It has a grayish white, broadened crab-like body.
- It has a distinctly enlarged claw on the end of the second and third pair of legs; within each claw is a thumb-like projection that enables the louse to grasp body hair (Figure 8.8 D).
- It is also called a crab louse.

LIFE CYCLE, HOSTS

- Females lay 30 to 90 eggs on coarse body hair (e.g., pubic and perianal regions, thighs, abdomen, and armpits), but will also infest facial hairs (e.g., eyelashes and beard) (Figure 8.8 E).
- Life cycle is completed in about 25 days.
- Adults will not live more than 24 hours after being removed from host.
- Pubic lice remain attached with their mouthparts in host skin for days at a time.

IMPORTANT CONSIDERATIONS

- Painless blue spots can appear after crab lice feed. Other evidence includes rust-colored insect excretions and darker spots in underwear and flakes similar to dandruff in pubic hair.
- They are transmitted from one person to another during sexual contact.

Management of Human Lice

Louse control is not a pest control operation because premise treatments are generally not required. Most often louse control involves a medical treatment of the infested individual using over-the-counter or prescription insecticidal shampoos and rinses made specifically for lice control. Common active ingredients include lindane, malathion, pyrethrins, and permethrin. Advise clients to contact their physician, pharmacist, or public health nurse. All infested family members should be treated at the same time to prevent re-infestation from one person to another.

Clients are encouraged to wash bedding (e.g., sheets, blankets, pillow cases), clothes, hats, scarves, and coats in hot soapy water and use a clothes dryer set on high heat (140° F). Discourage use of a common brush and comb, although most lice transfer is by direct body contact.

Regular combing is the oldest and safest method of head lice control, but this method requires time and patience. An electric comb (Robi Comb™ by LiceGuard™; Figure 8.8 F) is commercially available to detect live head lice.

For body lice, bathing and putting on freshly laundered, lice-free clothing are recommended.

In addition to items listed above, pubic lice management involves notification of a person's sexual partner(s).

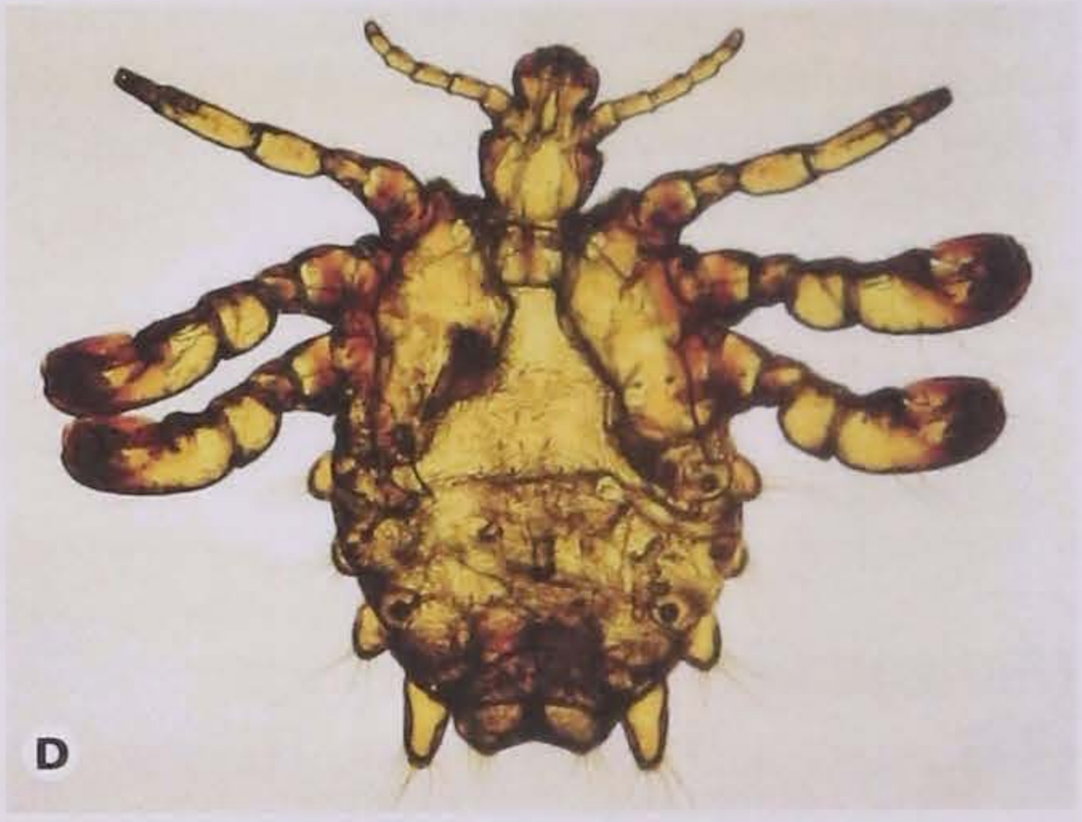


Figure 8.8. (A) Nit (louse egg) before hatching; (B) Pediculosis from body lice; (C) Head louse; D- Pubic/crab louse; (E) Pubic louse and nits on human eyelid; (F) Robi comb. Image credit: (A) Dennis D. Juranek, Centers for Disease Control and Prevention; (B) http://dermimages.med.jhmi.edu; (C) Gilles San Martin, Wikipedia Creative Commons; (D) www.bergen.edu; (E) www.glogster.com ; (F) www.momsfavoritestuff.com/

Mosquitoes

Mosquitoes are well-known biting pests found almost anywhere outdoors. They are generally small (< ½ inch; 13 mm) and fragile insects. Their most obvious characteristics include one pair of wings with scales on the wing veins and hind margin, and an elongated beak with piercing mouthparts (Figure 8.9). Mosquitoes are often confused with midges, gnats, and other flies.

Figure 8.9. Example of a mosquito; note scales on wing (inset).
Image credit: www.smcmad.org

Only adult female mosquitoes feed on blood; adult males feed on flower nectar. Mosquitoes have a complete life cycle. All life stages (except adults) are aquatic. Eggs may be laid on water or in areas that are prone to flooding, depending on the species. Larvae feed on organic matter found in standing water.

Mosquito Management

Effective mosquito control requires community-wide efforts, including elimination of breeding sites. Small areas can be treated using sprays, aerosols, or fogs.

Persons doing significant, area-wide mosquito control work should become certified in "Category 7D, Community Insect Control." Preparation for the certification exam should involve reading "Community Insect Management," Iowa Commercial Pesticide Applicator Manual, CS22.

Delusional Infestation

It is common to be approached by clients seeking (more often demanding) an insecticide treatment to cure bite-like skin reactions, itching, or skin irritations. The clients assert that these conditions have been caused by insects, but upon investigation, no insects or mites can be found. **Delusional infestation**, **illusory parasitosis**, or **Ekbom's syndrome** are three of many names used to describe these extremely emotional and sensitive situations. Other names used for the nonexistent arthropods include "paper mite," "sand flea," and "cable mite." There are no such animals and use of these names by a client should be a warning of a difficult situation. Use of these names by a PMP is unethical and a flagrant breach of professional conduct.

There are only a few biting insects that produce skin reactions and these are all large enough to be seen and readily identified. Common biting pests include fleas, head/body lice, pubic lice, ticks, bed bugs, bird mites, and mosquitoes. Obscure or microscopic organisms that may bite are possible (e.g., scabies mite, itch mite), but these can be isolated and identified by a dermatologist.

One characteristic of delusional infestation is a client's recent history of seeking relief through excessive treatments or bizarre remedies (e.g., spraying sheets with insecticide, washing clothing in gasoline, bathing with disinfectants). Another characteristic is the client's contact with several specialists (e.g., physicians, dermatologists, psychiatrists, entomologists, public health departments) yet without remedy of the skin symptoms. Finally, an inspection of the sufferer's environment and alleged specimens affirms the absence of an infestation.

Several studies and articles on this topic exist; you are encouraged to read more on this topic. Some of the most common causes of skin irritation are physical agents (e.g., dry air, detergents, cosmetics, fiberglass fibers), physiologic factors (e.g., allergy, disease), and psychological issues (e.g., anger, anxiety, stress).

When faced with this situation, advise clients to work closely with a dermatologist. Remember that the skin irritation or itching sensations feel real to the client. Treat all clients with sensitivity and concern. Always be honest in answering questions. Do not agree with clients that you see pests that are not there. NEVER apply a pesticide unless biting arthropods have been confirmed and identified by you. This could reinforce the client's belief that stronger pesticides will solve the problem. Ironically, they could shift from a fictitious pest to blaming the pesticide application as the cause of their suffering.

Solving mystery bug problems is seldom easy; it will be, more likely, frustrating and time consuming. A thorough investigation and referral to another professional specialist (rather than a quick pesticide application) is the best course of action.

Chapter 9
Stinging Pests

Learning Objectives

After studying this chapter, you should be able to

- Distinguish between bees and wasps
- Describe the social structure within honey bee hives
- Compare the bumble bee with the carpenter bee
- Contrast the adult size and common nest location of:
  - Yellowjacket
  - Bald-faced hornet
  - European hornet
  - Paper wasp
- Determine the common food source of wasps
- Name two wasp species that are generally not aggressive
- Discuss how to manage:
  - Bees
  - Wasps

Bees

Bees are beneficial insects (e.g., pollination, honey) but they can be problematic if they nest in or near dwellings due to the danger of stings. These insects have a complete life cycle. Bees have two pairs of wings, are hairy/fuzzy, and have a broad connection between the thorax and abdomen. Bees have chewing-lapping mouthparts and consume pollen and nectar (Figure 9.1 A).

Honey Bee (*Apis mellifera*)

IDENTIFICATION

- Honey bees are ½ to ⅝ inch (13 to 16 mm) long.
- Their color varies from dark brown to brown to brown intermixed with yellow. They have a thorax with dense hairs and sparser hairs on the abdomen, which is banded (Figure 9.1 B).

LIFE CYCLE, NESTING

- Social insects, these bees have three castes: queens (egg production), drones (males for mating only), and sterile workers (tend the young); 20,000 to 90,000 individual bees in a given nest.
- They construct their nests of wax combs in hollows (e.g., old trees, attics, soffits, wall voids, chimneys).

IMPORTANT CONSIDERATIONS

- Honey bees are beneficial insects because they pollinate many different crops and produce honey and beeswax.
- Stings (barbed stinger with poison sac attached) are used to defend themselves or the nest (Figure 9.1 C).
- Wax combs may melt and release honey, which may stain walls and attract **secondary pests** (e.g., larder beetles, carpet beetles)(Figure 9.1 D).

Bumble Bees (*Bombus* species)

IDENTIFICATION

- Bee is ¾ inch (19 mm) long.
- The bee's large robust body has several colored hairs giving it a fuzzy appearance. It has a black head, a yellow or orange and black thorax, and black and yellow or orange patterns on its abdomen (Figures 9.1 E, F).

LIFE CYCLE, NESTING

- Bumble bees are social insects that live in nests made in the ground (Figure 9.1 G), in mouse nests, old bird nests, clumps of dry grass or straw, or in soft materials (e.g., old mattresses, car cushions, rags).

IMPORTANT CONSIDERATIONS

- Bees are beneficial insects because they pollinate clovers and other flowers.
- Bumble bees sting when defending their nest. Their stingers, unlike those of honey bees, are not barbed.
- Nests can be located in a building or next to a building or along a walkway.

Carpenter Bees (*Xylocopa* species)

IDENTIFICATION

- Bee is ¾ to 1 inch (19 to 25 mm) long.
- It has a large robust body and a thorax with dense yellow or black hairs. The abdomen is shiny black and without the density of hairs seen on a bumble bee (Figure 9.1 H).

LIFE CYCLE, NESTING

- These solitary insects nest as a unit consisting of a female, male, and their offspring.
- Carpenter bees nest in unfinished softwoods (e.g., pine, cedar, redwood, cypress); wood is not consumed, but merely hollowed out; from entrance hole, tunnel turns 90° and extends up to 1 ft (31 cm) following the wood grain (Figures 9.1 I, J).

IMPORTANT CONSIDERATIONS

- Bees are beneficial insects because they pollinate flowers.
- They drill ½ inch (13 mm) holes into exposed wood causing damage to home, garage, or barn siding, fences, and other structures.
- They will re-infest same wood year after year.
- Females can sting if aggressively handled.
- Behavior of males is the first indication of carpenter bees nesting in the area: they will hover around the nest entrance and chase off any intruders; although aggressive, they are harmless since they lack a stinger.

Wasps

Like bees, wasps are considered beneficial insects because they serve as predators of many different insects and spiders. However, wasp stings are a serious health threat to humans and animals because they are more dangerous and unpredictable when compared to bees. Hundreds of people die each year in the United States from allergic reactions to wasp venoms.

Wasps of various types have a complete life cycle. Adults have two pairs of wings, are smooth or hairless, and have a narrow petiole (waist). Wasps have chewing mouthparts and consume pollen and nectar.

Social wasp colonies start from the work of a single, mated, overwintering queen. She constructs a small, paper nest for a few eggs. Larvae are fed by the queen, develop through the pupal stage, and emerge as sterile adult female workers. The new workers increase the nest size, scavenge for food, and feed the next developing offspring. A colony may reach 4,000 individuals

within a season. Males and new reproductive females are produced in early fall. After mating, the colony dies off and only the newly fertilized queens overwinter in sheltered sites. Abandoned nests are not re-used and disintegrate.

Solitary wasp species work alone to build a nest and provision it with food for offspring. Nests are much smaller than those of social wasps, and no workers are produced to care for the developing larvae.

Yellowjackets (*Vespula* or *Dolichovespula* species)

IDENTIFICATION

- This wasp species is ½ to ⅝ inch (13 to 16 mm) long.
- Adults are yellow and black in color, with banding on the abdomen. Some species have white and yellow markings (Figure 9.2 A).

LIFE CYCLE, NESTING

- Social insects build their nests in trees or shrubs, underground, in rock piles, in timber retaining walls, or in structural voids (e.g., attics, walls) (Figures 9.2 B-D).

FOOD PREFERENCES

- Yellowjackets prefer insects and spiders throughout the spring and summer, but turn to sugar sources (e.g., honeydew, ripening fruit) in the fall.

IMPORTANT CONSIDERATIONS

- This species exhibits aggressive behavior in protecting nest and securing food.
- Yellowjackets are considered the most dangerous stinging insect in the United States.
- Their nests in attics and wall voids attract dermestid beetles.

Bald-faced Hornet (*Dolichovespula maculata*)

IDENTIFICATION

- Adults are ⅝ to 1 inch (16 to 25 mm) long.
- Adults are black with white markings on the head, thorax, and abdomen (Figure 9.2 E).

LIFE CYCLE, NESTING

- Hornets build gray, football-shaped, aerial-paper nests that are attached to tree branches, shrubs, utility poles, or house siding. A nest consists of three to four internal tiers of combs housed within a thick, multilayered outer shell that has a single opening at the bottom; one nest may contain several hundred hornets (Figure 9.2 F).

FOOD PREFERENCES

- The bald-faced hornet species feeds on flower nectar, ripening fruits, plant sap, and insects.

Figure 9.1. (A) Close-up of bee head showing mouthparts; (B) Honey bee adult; (C) Barbed stinger of honey bee; (D) Honey bee nesting in wall void. Image credit: (A) Snomanda, http://snomanda.deviantart.com; (B) Vera Buhl, Wikipedia Creative Commons; (C) www.raymondhuber.co.nz; (D) www.bluelineapiary.com/blog

Figure 9.1. (E) Black bumble bee; (F) Yellow and black bumble bee; (G) Bumble bee hovering over entrance hole to ground nests; (H) Carpenter bee; (I) Carpenter bee nest entry hole; (J) Carpenter bee gallery in deck plank. Image credit: (E) Vaclav Stepansky, www.biolib.cz; (F) Pat Bonham, http://rxwildlife.org.uk; (G) Kathy Keatley Garvey, http://ucanr.edu/blogs/bugsquad; (H) www.waspweb.org; (I) Toby Otter, www.nativebeeconservancy.org; (J) GCMGA Inc., http://aggie-horticulture.tamu.edu/galveston

IMPORTANT CONSIDERATIONS
- Hornets will aggressively defend their nest if disturbed.
- Nests on siding or near high-traffic areas should be removed by a PMP at night.

European Hornet (*Vespa crabro*)

IDENTIFICATION
- This species is 1 to 1⅜ inches (25 to 35 mm) long.
- Adults have yellow heads with brown markings, a black thorax with brown markings, and a yellow and black banded abdomen (Figure 9.2 G).

LIFE CYCLE, NESTING
- These social insects build gray paper nests in some type of cavity, such as a hollow tree or wall voids. Occasionally the nest structure will extend outside of the void. One nest may contain several hundred hornets.

FOOD PREFERENCES
- The European hornet feeds on many insect species, ripening fruit, plant sap.

IMPORTANT CONSIDERATIONS
- Hornets will aggressively defend their nest if disturbed.
- They will girdle tree and shrub branches when gathering materials to build nest (Figure 9.2 H).

Paper Wasps (*Polistes* species)

IDENTIFICATION
- This species is ⅝ to ¾ inch (16 to 19 mm) long.
- Adults are generally brown with yellow, black, orange, or white markings. The wings often are smoky brown (Figure 9.2 I).

LIFE CYCLE, NESTING
- Social insects build open comb nests (inverted umbrella) under eaves of houses, porches, or windows, in shrubs, and in other protective places (Figure 9.2 J); nests can have 75 adults tending 200 cells.
- No castes are present, only females working together to assure success of the nest.

FOOD PREFERENCES
- Paper wasps feed on various insect species and flower pollen (especially goldenrod).

IMPORTANT CONSIDERATIONS
- Nests may be built in high-traffic areas.
- Paper wasps will sting when defending nest.

Mud Daubers

IDENTIFICATION
- Daubers are ¾ to 1 inch (19 to 25 mm) long.
- Adult coloration varies by species from dull black to black with bright yellow markings to iridescent blue-black. The best identifying feature is long, narrow petiole between the thorax and the abdomen (Figure 9.3 A).

LIFE CYCLE, NESTING
- Solitary wasps construct nests out of moistened soil in species-specific shapes; the mated female lays an egg in each cell and provisions with a paralyzed spider, then she seals the cell with more mud. The types of spiders used to provision a nest also is species specific for the mud dauber species (Figures 9.3 B-D).

FOOD PREFERENCES
- Mud daubers feed on flower nectar.

IMPORTANT CONSIDERATIONS
- Mud daubers are not aggressive and rarely sting.
- Presence of wasp in garages, on home sidings and other high visibility areas is considered a nuisance to property owner.

Cicada Killer Wasp (*Specius speciosus*)

IDENTIFICATION
- This wasp species is 1½ to 2 inches (38 to 51 mm) long.
- Adults are black with yellow markings on thorax and abdomen and have rusty colored wings (Figure 9.3 E).

LIFE CYCLE, NESTING
- Solitary wasp nests in soft, sandy soil (Figure 9.3 F).
- Each tunnel is 1 inch (25 mm) in diameter and extends 2 feet (0.6 m) into the ground. Tunnels may be branched and end in one or more globular cells. Each cell along this tunnel is provisioned with one egg and one or two paralyzed cicadas.

FOOD PREFERENCE
- Cicada killer wasps feed on nectar and pollen.

IMPORTANT CONSIDERATIONS
- Large wasp flying around trees near homes is considered a nuisance.
- Wasps do not sting unless handled or threatened.

Figure 9.2. (A) Yellowjacket; (B) Yellowjacket nest in old bottle carton; (C) Ground-nesting wasps near entrance of nest; (D) Wasp hovering near nest entrance in a building foundation gap; (E) Bald-faced hornet; (F) Bald-faced hornet nest in tree. Image credit: (A) Richard Bartz, Wikipedia Creative Commons; (B) Thomas Bresson, Wikipedia Creative Commons; (C) Katie (Nature ID), http://natureid.blogspot.com; (D) Quest Pest Management, http://qpm.ca; (E) www.allcountypestcontrol.com; (F) The High Fin Sperm Whale, Wikipedia Creative Commons

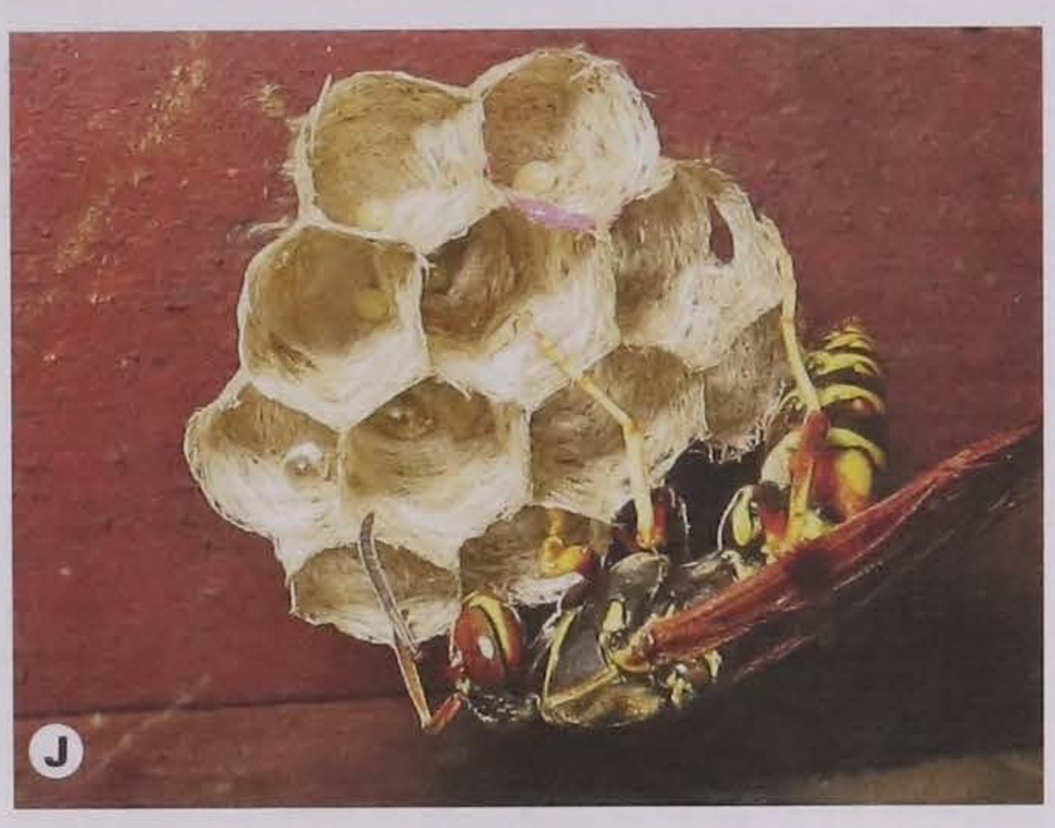


Figure 9.2. (G) European hornet; (H) Pair of European hornets stripping bark off tree; (I) Paper wasp; (J) Paper wasp nest. Image credit: (G) The LakeSide, www.flickriver.com/photos/nuclearlakeside/1175796840/; (H) Liz Cotton, http://afunnythinghappenedonthewaytothephoto.blogspot.com/; (I) Ken Thomas, Wikipedia Creative Commons; (J) Sainath Suryanarayanan, www.news.wisc.edu

Figure 9.3. (A) Mud dauber wasp making mud ball; (B) Mud dauber wasp on nest; (C) Organ pipe mud dauber nest; (D) Pair of organ pipe mud daubers provisioning nest; (E) Cicada killer wasp with prey; (F) Cicada killer wasp exiting nest. Image credit: (A) www.abundantnature.com/; (B) Victor French, www.unm.edu/~vscience/Campus%20Critters.htm; (C) Pollinator, Wikipedia Creative Commons; (D) Bea's Blogs, http://3.bp.blogspot.com; (E) Regina Alvarez, http://mariewinnnaturenews.blogspot.com/; (F) Rain Girl, http://4.bp.blogspot.com

Managing Stinging Pests

It is best to locate the entrance(s) to the nest during the day and conduct necessary treatments at night (when bees or wasps are sheltering within their nest). To be successful, all adults must be killed or the nest will be rebuilt and the process will begin again. Always wear a protective bee veil and heavy clothes when controlling a stinging pest to stop injury from stings.

Active ingredients of insecticides used to control stinging pests include 2-phenylethyl propionate, acephate, carbaryl, dichlorvos, ethofenoprox, nylar, pyrethrins, various pyrethroids (bifenthrin, bioallethrin, cyfluthrin, cyhalothrin, cypermethrin, deltamethrin, esfenvalerate, permethrin, phenothrin, prallethrin, tetramethrin), and sodium o-phenylphenate. Many formulations include a **synergist** that works with the toxicant to bring about kill; examples of synergists include piperonyl butoxide and MGK 264.

Bees

Honey bees may swarm in the spring. A swarm consists of thousands of workers and one queen. Although these massive accumulations of bees frighten people, honey bees are docile and nonaggressive at this time. It is best to call a beekeeper to collect the swarm for honey production.

For honey bees found nesting in a structural void, blow a dust formulation into this hole at night, but do not seal the nest opening. Dusts are effective because of the cleaning behavior of these insects. Once the bees are dead, open the wall and remove the nest to prevent wall staining and attraction of stored product pests. Seal the nest opening in the outside wall, as the void may be used by a future bee or wasp colony.

Carpenter bees are best controlled by applying insecticide dust into the entrance holes. You should plug the entrance hole with wood putty or a similar substance in the summer or fall to discourage use the next year.

Wasps

Yellowjackets, hornets, and wasps all may be managed with similar procedures. Treatment of individual nests in structures and in the landscape may be required if these are in high-traffic areas or otherwise interfere with normal human activities.

After dark, you should apply a registered insecticide to the nest opening and a 6-inch (15 cm) band around it. For aerial nests, wet the paper material thoroughly so all members of the colony contact the treatment. For ground nests, apply a dust formulation to the nest opening. Pressurized aerosols are also effective for small and/or exposed nests.

Do not seal the nest opening after treatment. This is especially important in structural situations because agitated wasps may emerge elsewhere inside a structure. Once all the wasps have died, seal opening(s) or fill voids to prevent future problems. Such exclusion techniques are also needed when wasps nest in hollow tubes, such as playground equipment or metal fences.

Inspect sensitive areas for paper wasp nests twice monthly from spring through early summer. Remove small nests by simply knocking them down. This will greatly reduce the number of large nests in these areas later in the season. Nests can be removed using vacuums if you have a way to safely dispose of the trapped insects.

Nests of the mud dauber wasp can be problematic for a client. If so, nests can be removed by scraping with a putty knife, destroying the existing nest(s), and encouraging the wasp to find a new location for future nests. Pesticide control is not warranted for this type of wasp.

Folk remedies, such as dousing nests with gasoline or a stream of water from a garden hose, seldom work and can result in multiple stings.

Parks, schools, supermarkets, and restaurants can use sanitation to minimize attractive food sources for foraging wasps. Trashcans should be equipped with plastic liners and tightly fitting (self-closing) lids. People eating outdoors should keep food and beverages covered, and clean up spills and leftovers promptly. Whenever possible, trashcans and dumpsters should be located away from serving tables, loading docks, concession stands, and other entrances. Maintaining high levels of sanitation earlier in the summer will make areas less attractive to foraging wasps later in the year.

Traps have shown only marginal benefits even though they will catch impressive numbers of yellowjackets when properly positioned and baited. Business establishments (e.g., outdoor cafes) may find these traps worthwhile when used with other approaches. Braunschweiger liverwurst combined with jelly has been an effective attractant.

Chapter 10
Spiders

Learning Objectives

After studying this chapter, you should be able to

- Define: cephalothorax, ballooning
- State how spiders differ from insects
- Identify by sight Iowa's two poisonous spiders
- Explain human health concerns associated with poisonous spiders
- List nonchemical control tools that can be used to manage spiders
- Name the insecticide formulations for use in spider management

Overview

Spiders are not insects, but are arthropods in the class Arachnida. They have eight legs, two body regions (**cephalothorax** and abdomen), no antennae, and no wings (Figure 10.1 A). Spiders are the most common arthropod seen by homeowners. They are considered very beneficial because they eat many insects.

A spider develops from an egg into an immature spider that may molt several times before becoming an adult. Newly hatched spiderlings are lightweight and can be carried on winds, especially when a small silk "balloon" is made by the spiders (referred to as **ballooning**; Figure 10.1 B). Others crawl away from the egg case seeking a site to feed and develop. Some spiders are active hunters while others are dependent upon silk webs to trap their prey.

Spiders are usually just a nuisance from their webbing and presence. Common accidental invaders include wolf spiders, jumping spiders, cellar spiders, and grass spiders. These may be alarming or disagreeable, but they are not dangerous.

In general, spiders will not attempt to bite humans unless held or accidentally trapped. Moreover, the majority of spiders have fangs too small or too weak to puncture human skin. There are, however, two species that are medically important because of their poisonous bite.

Poisonous Species

Brown Recluse Spider (*Loxosceles reclusa*)

Also called fiddleback spider or violin spider, the brown recluse occurs in the upper Midwest but is not commonly observed. These spiders have been moved in furniture and boxes from warmer parts of the United States.

IDENTIFICATION

- Adult spiders are ¼ to ½ inch (6 to 13 mm) long.
- Cephalothorax has 6 eyes arranged as 3 pairs; light brown with a dark brown violin-shaped marking on top of cephalothorax; 4 pairs of long legs; abdomen is uniformly colored light to dark brown (Figure 10.1 C).
- Immature spiders are light but gradually darken as they mature.

LIFE CYCLE

- A female places 50 yellow eggs in a white, silken sac. She will produce 1 to 5 egg sacs.
- This spider completes a single generation each year.
- Spiders can live up to 2 years.

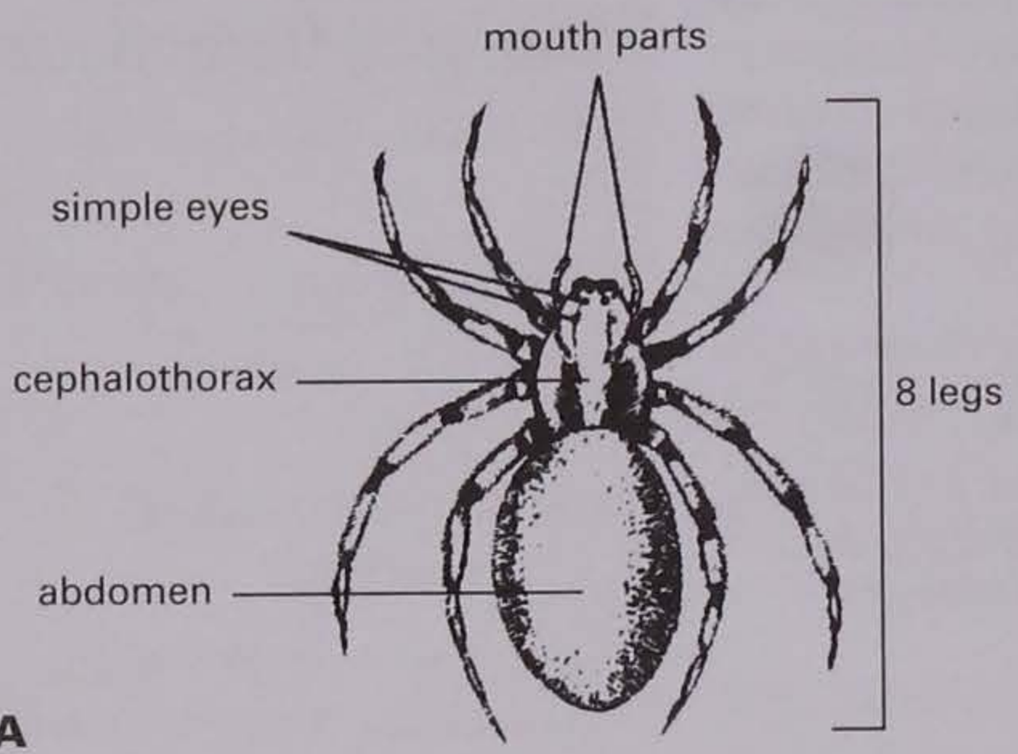


Figure 10.1. (A) Spider anatomy; (B) Spider in position to balloon from site; (C) Brown recluse spider; (D) Black widow spider. Image credit: (A) www.arthursclipart.org; (B) http://mind-ensnare.deviantart.com; (C) Br-recluse guy, Wikipedia Creative Commons; (D) Chuck Evans, Wikipedia Creative Common

NATURAL HABITAT, HOSTS

- This species is generally secretive, occupying dark, undisturbed sites:
  - Indoor sites include attics, basements, crawl spaces, cellars, closets, ductwork, storage boxes, clothing, gloves, shoes, folded linens, and behind furniture;
  - Outdoor sites include barns, storage sheds, garages, under logs, in rock piles, or in stacks of lumber.
- The brown recluse spider spins a loose, irregular web of very sticky, off-white to grayish threads to create a daytime retreat.
- The spider hunts at night for insects and other small arthropods and also will scavenge dead/dying insects.

MEDICAL CONCERNS

- The bite is poisonous.
- Symptoms vary in severity, and may exhibit: no reaction; a small red mark; a painful, slow-healing, deep wound; or tissue death at the site of the bite.
- Fatalities are extremely rare but bites are dangerous to children, the elderly, and those in poor physical condition.

Black Widow Spider (*Latrodectus mactans*)

This spider is considered the most venomous spider in North America, although human mortality is less than one percent from its bite. The black widow has been reported throughout North America, but is more common in warmer climates; only a few records exist from southern Iowa.

IDENTIFICATION

- Adult spiders have a ½ inch (13 mm) body and 1½ inch (38 mm) legs.
- Adult females are shiny, jet black with an abdomen having two connected triangles on the underside that form its characteristic hourglass marking. The hourglass color varies from yellow to red to orange (Figure 10.1 D).

LIFE CYCLE

- The female spider normally does not consume the male after mating.
- The female places 25 to 250 eggs in a globular, silken sac that is suspended in her web.
- Spiderlings live in the web for one molt and then disperse by ballooning.

NATURAL HABITAT, HOSTS

- A female constructs a web of crisscrossed silk threads with no recognizable pattern and suspends herself upside down at night and waits for prey.
- Webs are situated outdoors near the ground in a dark, sheltered site such as woodpiles, rubble piles, under stones, in hollow stumps, rodent burrows, outbuildings, and window wells. Indoors, females prefer undisturbed basements and crawlspaces.

MEDICAL CONCERNS

- The bite is poisonous.
- Symptoms vary from no reaction to a short stabbing pain to serious complications. Other symptoms may include nausea, profuse perspiration, abdominal cramping, tremors, labored breathing, restlessness, increased blood pressure, and fever.
- Long term complications and death are very rare.

Figure 10.2. (A) Vacuuming spider cobwebs as a management tool; (B) Vines growing near windows.
Image credit: (A) Alexson, http://2.bp.blogspot.com; (B) Sara at Russell Street Reno, http://1.bp.blogspot.com

Spider Management

There are several non-chemical tools you can use to manage spiders in a facility. These include:

- Remove webbing with a broom or vacuum; control the insects that serve as food within a structure (Figure 10.2 A).
- Clean and re-arrange storage areas and basements regularly.
- Place sticky traps around the inside of basement and ground level rooms to monitor spider activity.
- Install tight-fitting screens on doors and windows, and adjust door threshold seals to prevent entry.
- Install yellow incandescent or sodium vapor lights near a structure.
- Remove ivy or other heavy vegetation on the foundation or building walls (Figure 10.2 B).
- Avoid storing piles of lumber, firewood, or stones near a structure.
- Check boxes, furniture, and other items that have been in storage for egg cases and spiders before bringing these into a building.

Chemical control of spiders has mixed results. Residual liquid sprays applied to the inside/outside perimeter of a structure are generally not effective since spiders do not pick up a lethal dose in moving from place to place. Any insecticide application MUST contact the spiders in their webs or hunting spiders directly. Active ingredients that are registered in Iowa for spider control include baygon, carbaryl, DDVP, dinotefuran, limonene, pyrethrins, and several pyrethroids (bifenthrin, bioallethrin, cyfluthrin, cyhalothrin, cypermethrin, deltamethrin, esfenvalerate, imiprothrin, permethrin, phenothrin, and prallethrin).

Learning Objectives

After studying this chapter, you should be able to

- Define: commensal, omnivores, kinesthetic sense, bait translocation, anticoagulant, paraffinized bait, secondary hazard
- Describe the human health concerns from rodent infestations
- Identify the damage to human foods by mice and rats
- Give examples of structural damage done by rodents
- Identify four common places rodents can enter a structure
- Distinguish:
  - Rodents that must have access to free water
  - Rodents that acquire water from their food
- State the normal activity periods of commensal rodents
- Name the two primary commensal rodents infesting a structure
- Differentiate between the deer mouse and the meadow vole
- List seven capabilities of commensal rodents
- Name six ways to determine if rodents have infested a structure
- Tell why autumn increases the problems with commensal rodents
- State why monitoring tools should be free of pesticide residues
- Describe how pest management is affected by landscaping
- Compare:
  - Anticoagulant and non-anticoagulant rodenticides
  - Food bait and water bait rodenticides
  - Detection blocks and tracking powders

Chapter 11
Rodents

Overview

Domestic rodents constitute a major **vertebrate** pest problem due to their adaptability, damage potential, and transmission of diseases. Rats and mice are remarkably well adjusted for living in close association with humans, thus being called **commensal** rodents. They live in granaries, fields, city sewers, attics, basements, street trees, on top of multistory buildings, and inside subway tunnels (Figure 11.1). Rodents eat almost every food that humans, pets, and livestock eat.

The greatest economic loss is not how much rodents eat but what must be thrown out because of damage or contamination. Rats and mice also damage doors, walls, insulation, and other structural components by gnawing and burrowing. They also gnaw through utility pipes and electrical wiring causing fires, indoor flooding, power outages, and equipment failure.

Rats and mice can also transmit diseases, most notably salmonellosis (bacterial food poisoning), when infected feces and urine contaminate food. Other rodent-borne diseases include plague, murine typhus, rat-bite fever, rickettsial pox, Hantavirus, lymphocytic choriomeningitis, leptospirosis, scrub typhus, and tularemia.

Figure 11.1. Mice on wall. Image credit: http://meetyourmouse.files.wordpress.com

Major Rodent Pests

Norway Rat (*Rattus norvegicus*)

This is the largest domestic rodent species found and is described as robust, hardy, aggressive, and sly. It is also called the common rat, barn rat, gray rat, brown rat, house rat, sewer rat, wharf rat, and ship rat (Figures 11.2 and 11.3 A).

IDENTIFICATION

- Adult total length is 13 to 18 inches (33 to 46 cm).
- Weight is 7 to 18 ounces (198 to 510 g).
- Snout is blunt.
- Tail is shorter than the head plus the body and measures 6 to 8.5 inches (15 to 22 cm) long. It is light underside.
- Ears are small, close set, and appear half buried in fur; they do not reach the eyes.
- Fur color is reddish brown to gray brown with the belly a yellowish-white.
- Droppings are ¾ inch (19 mm) long and blunt on each end.

LIFE CYCLE

- The rat's life span is 5 to 12 months.
- Females are sexually mature in 2 to 3 months and can produce 4 to 6 litters each year with 6 to 12 pups per litter.

Outdoors, Norway rats commonly nest in burrows alongside buildings, fences, sidewalks, and under bushes or debris. Their ground burrow system consists of a central den, a primary entrance, and two or more escape holes. They follow the same routes daily causing a distinct, well-beaten path. Indoors, this species prefers to nest in the lower portions of a structure in wall voids, underneath floors, in crawlspaces, and beneath or inside equipment or stored items.

Norway rats are **omnivores**, consuming as many different types of foods as they encounter. In natural areas, rats will eat cereal grains and various plants. In the urban environment, they eat meats, vegetables, and cereal grains, as well as garbage. Norway rats require water each day when feeding on dry food in the amount of 0.5 to 1.0 ounce (15 to 30 ml) per day. The average rat consumes 0.5 to 1.0 ounce (15 to 30 g) of food/day. Their foraging range from the nest is 50 to 150 feet (15 to 45 m).

Roof Rat (*Rattus rattus*)

This rat has been described as sleek, graceful, and elusive. Other common names include the black rat, ship rat, and house rat. There are three subspecies that make up what is known as the roof rat: the black rat, the Alexandrine rat, and the fruit rat. The roof rat (Figures 11.2 and 11.3 B) does not occur in the upper Midwest but is very common in coastal cities and seaports. It is included here as a potential structural pest.

IDENTIFICATION

- Adult total length is 13 to 18 inches (33 to 46 cm).
- Weight is 5 to 9 ounces (142 to 255 g).
- Snout is pointed.
- Tail is longer than the head plus the body and measures 7.5 to 10 inches (19 to 25 cm) long. It has uniform coloring top and bottom.
- Ears are large, prominent, stand out well from fur; ears can be pulled over eyes
- Fur color is black to slate gray and is tawny above and gray white below.
- Droppings are ½ inch (13 mm) long and pointed on each end.

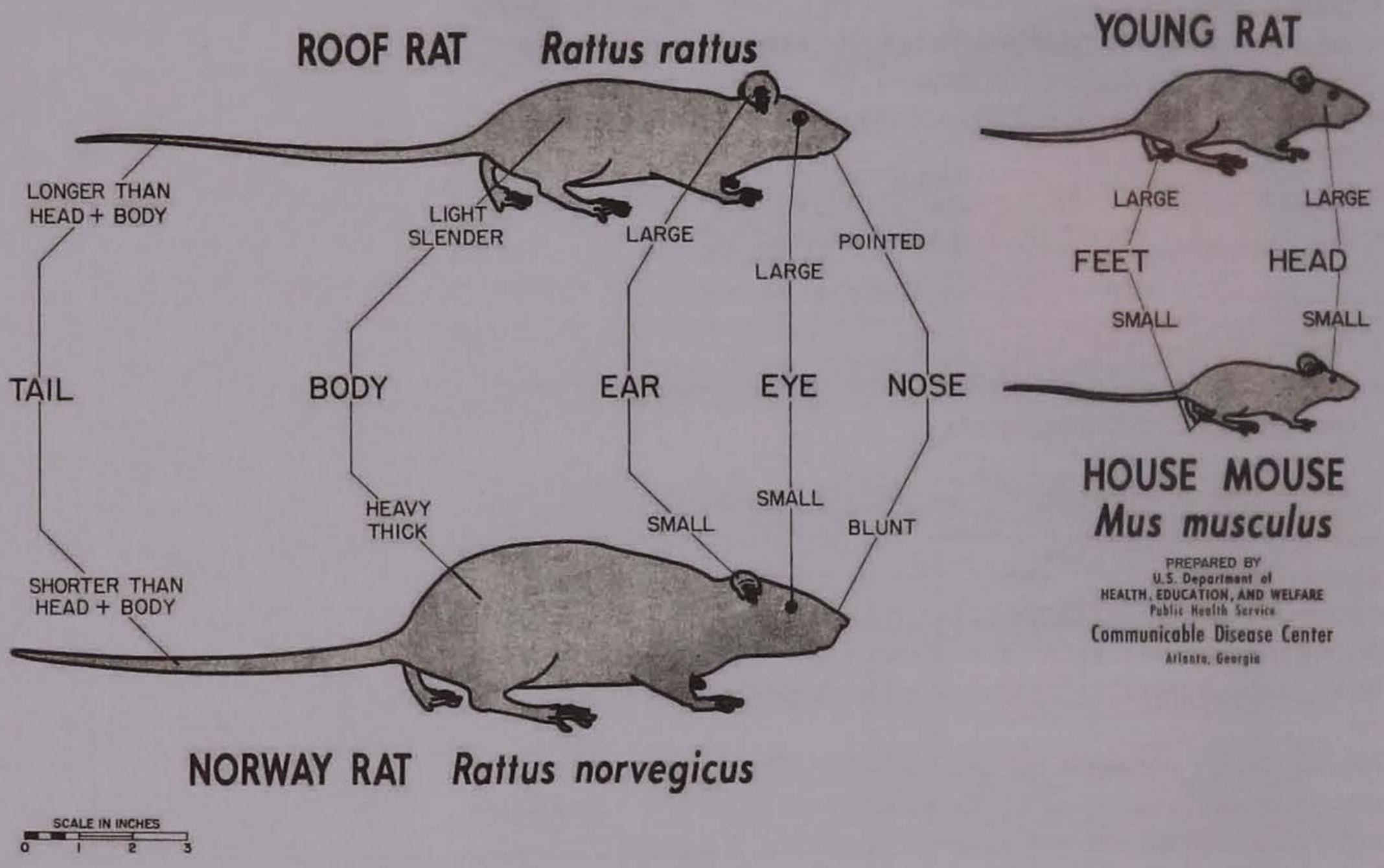


Figure 11.2. Field identification characters of domestic rodents. Image credit: Centers for Disease Control, Atlanta

LIFE CYCLE

- The rat's life span is 5 months to 1.5 years.
- Females are sexually mature in 3 months and can produce 3 to 4 litters each year with 4 to 8 pups per litter.

Roof rats are excellent climbers and are usually found above ground level. They usually enter a structure by using tree limbs, utility lines, or fences. Nests may be located indoors in attics, roof areas, or ceiling voids. Outdoors, roof rats nest in trees, vines, or on the roof or sides of a building. Occasionally, this species will nest in underground burrows like the Norway rat.

Roof rats consume many types of foods, but prefer vegetables, fruits, cereal grains, and seeds. Although rats are generally opportunists when it comes to food, the roof rat can exist more independently of humans than the Norway rat. Where slugs, snails, large cockroaches, fish, and shellfish are abundant, these items serve as a mainstay of the roof rat diet. The average daily consumption for this species is 0.2 to 0.8 ounce (7 to 15 g).

F

Figure 11.3. (A) Norway rat; (B) Roof rat; (C) House mouse; (D) Deer mouse; (E) Meadow vole; (F) Pine vole. Image credit: (A) www.orkin.com; (B) Klaus Rudloff, www.biolib.cz; (C) Zac Allain, www.britishwildlife.wikia.com; (D) Gene Ott, www.snakesandfrogs.com/scmammals/scmamal.htm; (E) Derek Stoner, http://02b93fb.netsolhost.com/blog; (F) www.adamspestcontrol.com

House Mouse (*Mus musculus*)

One of the smallest, common domestic rodents, the house mouse is a delicate, agile rodent that has been labeled a mammalian weed because it is so successful in adapting to changing human environments (Figures 11.2 and 11.3 C).

IDENTIFICATION

- Adult's total length is 5 to 8 inches (13 to 20 cm).
- Weight is 0.4 to 1 ounce (11 to 28 g).
- Snout is pointed.
- Tail is equal to or slightly longer than the head plus the body, measuring 3 to 4 inches (8 to 10 cm) long. It is scaly and sparsely haired.
- Ears are prominent and large for the animal's size.
- Eyes are inconspicuous.
- Fur color is dusky gray and is silky.
- Droppings are ⅛ to ¼ inch (3 to 6 mm) long and pointed on at least one end.

LIFE CYCLE

- Life span is 1 to 2 years.
- Females are sexually mature in 6 to 10 weeks and can produce 6 to 10 litters in a lifetime with 5 to 6 pups per litter.

Outdoors, the house mouse lives among weeds and shrubbery or near building foundations, inside garages, crawlspaces, or outbuildings. When food becomes scarce in the fall, these mice move indoors. Inside buildings, house mice commonly nest in wall, ceiling, or cabinet voids, in furniture, storage boxes, and in large appliances (e.g., stove, refrigerator, dishwasher).

Mice feed on a wide variety of food. Outdoors, they feed on seeds and cereal grains. Indoors, mice consume most human and pet food, as well as some common invertebrates found in buildings (e.g., cockroaches, slugs, snails). They are fond of foods high in fats, proteins, and sugars. House mice are nibblers and may make 20 to 30 visits to different food sites each night. House mice eat 0.05 to 0.10 ounce (2 to 4 g) of food daily. Their foraging range from the nest is 10 to 30 feet (3 to 9 m).

Unlike other commensal rodents, the house mouse is able to conserve water and obtain water from its food when free water is scarce or unavailable.

Deer Mouse (*Peromyscus maniculatus*)

Named for a similar coloration to the common white-tailed deer, the deer mouse is common and is "hamster-like" in appearance (Figure 11.3 D). These small rodents are reservoirs for Hantavirus pulmonary syndrome. Related species: white-footed mouse, *Peromyscus leucopus*.

IDENTIFICATION

- Adult's total length is 5 to 8 inches (13 to 20 cm).
- Weight is 0.5 to 1 ounce (15 to 28 g).
- Snout is pointed.

- Tail measures 2 to 4 inches (5 to 10 cm) long and is dark above and white beneath.
- Ears are large, conspicuous, and sparsely furred.
- Eyes are large, black, and protruding.
- Fur color is grayish brown on top with white undersides and white feet.

LIFE CYCLE

- Life span is 2 months to 4 years.
- Females are sexually mature in 7 to 8 weeks and can produce 2 to 4 litters per year with 3 to 5 pups per litter.

Deer mice nest outdoors in fence posts, tree hollows, log piles, abandoned bird or squirrel nests, and beneath decks and outbuildings. Indoors, these mice can be found in basements, attics, storage boxes, furniture, wall voids, sill plates, structural corners, unused equipment, and other tight spaces. Trees, vines, and large shrubs are used by this species to gain access to the upper areas of buildings for nesting. **Runways** are poorly defined, as this species uses runways of other small mammals.

Seeds, nuts, berries, insects, and other animals (e.g., dead mice, young birds) constitute the natural diet of deer mice. Indoor food sources also include pet food and various dropped food crumbs left by humans. Home range varies from 0.5 to over 1.5 acres (0.2 to 0.6 hectares).

Meadow Vole (*Microtus pennsylvanicus*)

Although there are four species of "field mice" common across the United States, the meadow vole is the most widely distributed and important pest species. Meadow voles (Figure 11.3 E) are described as less agile and have larger, chunky bodies when compared to the house mouse. Related species: pine vole, *Microtus pinetorum* (Figure 11.3 F).

IDENTIFICATION

- Adult total length is 5 to 8 inches (13 to 20 cm).
- Weight is 0.5 to 1 ounce (15 to 28 g).
- Snout is blunt.
- Tail is relatively short compared to the house mouse. It is twice the length of the hind foot, measuring 1.5 to 2.5 inches (4 to 6.5 cm) long.
- Ears are large and conspicuous.
- Eyes are large.
- Fur color is a dull, yellowish brown above with gray underside.

LIFE CYCLE

- Adult life span is 2 months to 1 year.
- Females are sexually mature in 6 to 8 weeks and can produce 3 litters per year with 3 to 5 pups per litter.

The meadow vole nests outdoors beneath shrubs or other dense vegetative cover yet will also nest below ground at the end of shallow burrows. Their runways are well defined, often seen in turf leading away from dense cover. This species is not known to nest indoors.

Food sources for meadow voles include grasses, seeds, fruits, fleshy rootstocks, and tree bark. Home range varies from 0.5 to 1.5 acres (0.2 to 0.6 hectares).

Capabilities

Rodents can sense and move in their environment with great efficiency. Learning how they do this and what their limitations are will give you clues on managing them.

Senses

The sense of touch is well developed in highly sensitive whiskers (**vibrissae**) and certain **guard hairs**. This enhances the rodent's ability to move rapidly in the dark. Rats and mice prefer to run along walls or between things where they can keep their sensory hairs in contact with side surfaces. An exception is the deer mouse that does not follow well-defined runways.

Kinesthetic sense refers to a rodent's process of exploring and learning about it environment as a way of ensuring survival. The animals explore their surroundings and remember the location of runways, food, water, harborage, and obstacles. Rodents even develop "muscle memory"—memorizing the muscular coordination needed to maneuver through their territory, sticking to frequently used routes (Figure 11.4).

Figure 11.4. Rodents memorize their territory using kinesthetic sense. Image credit: www.orkin.com

Rodent vision is adapted to nocturnal life. Their vision is not sharp, but is very sensitive to light. Rodents can also detect motion in dim light. The limit of their vision is 30 to 45 feet (9 to 14 m). They are color blind, so any distinctive coloring of poison baits does not reduce their acceptance provided the dyes do not have an objectionable odor or taste.

The sense of smell is keenly developed in rats and mice. They will leave odor trails of urine or other secretions to mark trails, delineate territories, and detect sexually active mates. Commensal rodents have adapted to the smell of humans, so human odor on baits or traps does not repel them. However, the scent of cigarettes, strong soaps, or cologne will make baits less attractive. An attractive food odor can help draw rodents to bait, providing the odor is not too strong and does not detract from the taste of the bait.

Rodents also have a well-developed sense of taste. In fact, taste is probably the most important factor in bait acceptance. Food preferences will vary among rodent species and even between different populations of the same species. Rats prefer fresh food to decayed food; keep baits fresh.

Rodents can detect sounds outside of the human range of hearing (ultrasonic sounds). They use these sounds for **echolocation** in darkness or for nocturnal orientation, though not as well as bats do. Young rats emit ultrasonic distress signals to call the mother to the nest. Unusual noises cause rodents to attempt escape.

Abilities

Rodents gnaw almost anything they can bite. The incisor teeth of rats grow 4 to 5 inches (10 to 13 cm) a year, so these rodents must grind the upper and lower incisors against each other to keep their incisors filed down. Rodents do not have to gnaw on objects to keep their incisors fit for use.

Rodents rely on gnawing as a means of survival (Figures 11.5 A, B). They use their incisors to gain access to harborages, obtain daily resources (e.g., food, water, and nesting materials), assist in climbing, and for defense. Unfortunately, rodents also chew on utility wires, computer wires, and electrical wires in our vehicles resulting in fires and inability to use equipment (Figure 11.5 C).

Gaining access to areas of a building or a food supply is another ability of rodents. A house mouse can squeeze through any opening that is larger than ¼ inch (6 mm). A rat needs ½ inch (13 mm) or larger hole. Rodents can make or expand holes by gnawing to obtain the food or shelter they need.

Rodents' ability to jump, climb, swim, and keep balance extends their territory and the range of areas they can reach in their environment. With a running start, Norway rats can jump vertically 3 feet (0.9 m), roof rats 4 feet (1.2 m), and house mice 1 foot (0.3 m). Norway rats can jump horizontally 4 feet (1.2 m) and can reach up 18 inches (46 cm).

Rats and mice can climb any vertical surface where they can get a claw hold, and descend head first down a rough wall. Norway rats can climb inside vertical pipes with diameters between 1½ and 4 inches (3.8 to 10 cm) and along the outside of vertical pipes up to 3 inches (8 cm) thick.

These extreme feats of climbing and jumping are usually done when the rodent is under stress (e.g., hunger, in need of shelter). Roof rats and house mice are better climbers than Norway rats, which will climb when necessary. Deer mice are excellent climbers and will often enter a building through high access points.

Commensal rodents have excellent balance. Roof rats can walk along suspended wires (e.g., telephone wires). Rodents can travel between rooms or buildings on plumbing and utility lines (Figure 11.5 D), can walk on narrow ledges, or crawl along ropes of various sizes.

All commensal rodents can swim, but the Norway rat is the best among them. They are able to dive and stay under water for at least 30 seconds; this allows the rats to enter buildings through sewer lines, floor drains, and toilet bowl traps. These rats can also swim through ½ mile (0.8 km) of open water and tread water for 3 days.

Norway rats prefer to burrow in the soil for nesting and harborage (Figure 11.5 E), while the roof rat does so occasionally. Burrows are found in earth banks, along walls, under rubbish or concrete slabs, and in similar places. Nest burrows rarely go deeper than 18 inches (46 cm). While individual burrows are usually shorter than 3 feet (0.9 m), established burrows may be longer and interconnected with several exit holes.

Behavior

Social Behavior of Rats

Rats are aggressive and very competitive. They live in colonies with well-defined territories that they mark with urine and glandular secretions. The colony has a social **hierarchy** with a dominant male leader and a "pecking order" of less dominant males and ranking females. The strongest and most dominant animals occupy the best nest and resting sites, and feed at their leisure. Weaker rats are pushed to less favorable sites or forced out of the territory completely. Social conflicts are most common at feeding sites, prime resting areas, and territorial boundaries. Females fiercely defend their nest and young from other rats.

Knowing the social hierarchy in rat populations will help you focus your management efforts. If you take time to locate the "choice" territories and focus on eliminating the dominant rats, the population will collapse into a smaller area. Then you need to remove the remaining rats (once kept on the fringe by social dominance) that migrate into the choice territories.

Confining control efforts to a smaller area can mean less time, less expense, and less risk of exposure among both people and nontarget organisms.

Figure 11.5. (A) Rodent gnawing around plumbing lines; (B) Rodent damage to stored chocolate bars; (C) Electrical wires damaged by rat gnawing; (D) Mouse coming from wall void via plumbing line; (E) Norway rat burrow entrances.
Image credit: (A) http://lifeintheratshole.com; (B) www.ffa.org; (C) http://georgia-paws.com; (D) http://rhymeswithsafari.files.wordpress.com; (E) www.msmosquito.com/galleries/rats

Activity Periods

Generally, commensal rodents are nocturnal animals, but they are highly adaptive. If food is readily available ONLY during the day, they will adjust their feeding/foraging schedules. Competition may also influence activity. When populations are high, some individuals may not be able to compete with all the others at night and so may be forced to forage during the day.

Dominant individuals are most active within two hours after sunset and again for a few hours before sunrise. Less dominant individuals are forced to forage between these times. The poorest competitors in a population have to look for food during the day when they can be most easily detected.

Response to Strange Objects

Rats are wary of any new object or sound that appears in their territory for three or more days. "New-object reaction" occurs whether you are placing a series of traps or with unintentional littering (e.g., a block of wood left from a construction project). This is a good example of how kinesthetic memory plays a protective role for the rodent. Anything new in the rat's environment will be noticed.

Mice tend to travel over their entire territory nightly, investigating each change or new object. Unlike rats, they show no fear of new objects or sounds. They dart from place to place, covering the same route over and over again. You will quickly learn that mice are more likely to be caught in newly set traps when compared to rats.

Rats may display less of the new-object reaction in environments where change is constant, as in warehouses or grocery stores with rapid turnover of inventory or when rodent populations build to the point of food scarcity. Still, the more cautious rats are the hardest to remove from a site and the more curious individuals usually succumb to trapping.

Feeding Behavior and Hoarding

Rats are less likely than mice to go after new food sources. They prefer the familiar, but will feed on a range of sources available rather than restrict themselves to a single food source. This means that any other available sources will provide competition for even the most palatable baits. After overcoming their initial fear of a new food source, rats will still only sample the bait, taking small amounts. If they get sick, the rats will avoid the bait completely.

Rodents hoard food. They may take the food back to harborage to avoid predators, to keep the food from competing rodents, or to store in case the food supply diminishes or is eliminated. Hoarding occurs with all foods of all different shapes or sizes, but large particles, pellets, or food packets are most susceptible to hoarding. House mice regularly move foods to nearby corners or other areas where they feel secure while eating. Deer mice are known to carry food stuffed into pouches in their cheeks and make **caches** (hidden supplies) for later consumption.

The rodents may not be eating as much bait as you might think based on how much of it is disappearing from bait stations. Hoarding may also result in the bait being taken to places that could expose nontargets, such as into a food-processing area or room frequented by children and pets. This movement of bait from one area to another is referred to as **bait translocation**.

Signs of Infestation

Because rodents are habitually nocturnal and secretive, it is necessary to interpret signs of their activities properly in order to plan management work. These signs are found in secluded places, such as along walls, under piles of rubbish, and behind or under boxes, boards, thick vegetation, or unused equipment. These signs can give you information about the species involved, the level of infestation, and if the infestation is still active. Night inspection confirms rodent activity suspected during a daytime inspection.

Dead or Active Rodents

Dead rodent carcasses are an indication of a current or past infestation. If all that you find are old, dried carcasses and skeletons, it usually means an old infestation. A rodent population is still active (and likely at high levels) if you see rats and mice during the day or if dead carcasses are still fresh.

Sounds

When a building is quiet, various rodent noises may be heard. These include squeaks, sounds of rodents fighting, clawing, scratching, gnawing, scrambling inside walls, and running across ceilings. Pets are often alarmed at these sounds before their human counterparts.

Droppings

Droppings are the most common sign of a rodent infestation. These pellets are durable and are left wherever rodents travel or rest. The size and shape of the droppings indicate the species of rodent you are dealing with and the numbers give a general indication of the population size. A single rodent will produce 50 or more pellets each day. Fresh fecal pellets are usually moist, soft, shiny, and dark. Older droppings are dull, grayish, and crumble when pressed.

Urine Stains

Rodents use urine to mark odor trails and territory, so wherever they travel they leave dribbles and spots of urine.

House mice tend to urinate in the same spots along their runways (Figure 11.6 A). Urine, dirt, and grease build up to form "urine pillars." Discovery of such pillars is a reliable indication of heavy mouse activity.

Both wet and dry rodent urine stains will "glow" blue-white under an ultraviolet ("black") light (Figure 11.6 B). Portable black lights are used in the food industry to identify rodent urine on food items. Other substances (e.g., cleaning solutions and detergents) may also glow under this light, so look for droplets and occasional pools symptomatic of rodent activity.

Runways and Rub Marks

Rodent runways alert the pest manager to food, water, and harborage locations. A key rule when inspecting for rodent travel ways is "rodents travel along lines." Outdoors, these lines could be ledges, sill plates, tree branches, utility lines, sewer lines, building perimeters, and edges of hard surfaces (e.g., sidewalks, parking areas, landscape stones). Smooth, well-packed, vegetation-free pathways are often indicative of Norway rats or meadow voles (Figure 11.6 C). Indoors, search for lines at junctures of walls, floors, and ceilings, as well as temporary lines made by pallets and various containers.

Grease marks (or rub marks) from the body oil and dirt of rats and mice often appear along walls next to runways. Rub marks may also be seen around bottom of joists, along beams or sill plates, on stairways, on walls near garbage dumpsters, or around burrow openings in walls, floors, or ceilings (Figures 11.6 D, E). Norway rat rub marks are most common on ground level areas, while the roof rat makes swing marks beneath beams and rafters at the point they connect to walls.

Fresh rub marks are soft and will smear if rubbed. Older rub marks flake off when scratched with a fingernail. Undisturbed spider webs and dust in a runway indicate that it is not currently being used.

Tracks

A rat's hind footprint is ¾ to 1½ inches (19 to 38 mm) long, while a house mouse hind footprint is ⅜ to ½ inch (10 to 13 mm) long. The number of toes on the hind footprint is five and that for the front footprint is four. The hind foot is typically the most visible print because this is where most of the weight is placed as the rodent travels about. In mud or food dust, the foot's toes and digits are very visible and can be counted easily. Rats may also leave a tail drag line in the middle of their tracks.

Gnaw Marks

When rodent gnawing marks are fresh, they are lightly colored, have sharp edges, and show distinct teeth marks (Figure 11.6 F). Small chips of wood or other materials on the surface below also indicate recent gnawing. Mice will make gnaw marks that are 1/16 inch (1.5 mm) apart, appearing as scratch marks. Rat gnaw marks are ⅛ inch (3 mm) apart. With age, wood gnawing marks become dark and smooth from weathering and from frequent contact with the rodent's body.

Burrows

Burrows indicate an obvious presence of Norway rats in outdoor infestations. Mice will sometimes burrow, but the openings are much smaller (1 inch; 25 mm) compared to rat burrows (3 to 4 inches; 8 to 10 cm).

If a burrow is in use, its entrance will be free of spider webs and dust, and you can see fresh rub marks on compacted soil. The presence of fresh food fragments, recent rodent droppings, and freshly dug earth (especially with tracks in it) at the burrow entrances will also indicate current use. To verify an active burrow, stuff a few wads of paper into the entrance or cave in the entrance; recheck these sites within two days.

Two common sites for rat burrows on private property are near bird feeders and by dog houses. Deer mice and meadow vole burrows are often seen around ornamental plantings and at the base of decorative or production fruit trees.

Odor

A distinctive, musky odor is common where rodents are present. Urine is a large contributor to this smell. With practice, the odor of rats can be distinguished from that of mice.

Managing Rodents

Site Management

Rodents must have adequate food, water, and harborage to live and multiply. It follows that anywhere there is an abundance of resources there can be an abundance of rodents. Removing or reducing available food and harborage with good sanitation and rodent proofing will negatively impact the rodent population. Failure to combine these necessary elements will cause rodent management to fail in spite of other control tactics.

SANITATION

Sanitation (removal of food, water, and harborage) directly limits the growth of rodent populations and also enhances other management efforts. For example, removing other food sources increases the odds that rodents will feed on rodenticide baits. Even the best baits are not able to compete with acceptable food sources.

Involving the client in rodent management to improve sanitation includes the following.

- Close or repair dumpsters and garbage containers. The tighter the lid fits on these devices, the less likely a rodent can access food and exit the container (Figure 11.7 A).
- Move garbage dumpsters as far away from a building entry door as possible; a minimum of 25 yards (22.5 m) is recommended.
- Place food trash in plastic bags prior to being placed in the dumpster.
- Clean up food spills (inside and outside buildings).
- Do not allow pet foods to be left out overnight.
- Store bulk foods (e.g., flour, sugar) and pet foods (including bird seed) in rodent-proof containers.

Figure 11.6. (A) Rodent urine and feces; (B) Fluorescent powder shows rodent activity; (C) Vole runways in grass; (D) Rodent grease marks around beam; (E) Multiple grease marks along basement wall; (F) Mouse gnawing on boxed soap. Image credit: (A) http://takeairinc.com; (B) http://bristolpestcontroller.co.uk; (C) www.olyrose.org/garden_residents.htm; (D) http://howgreencanyoubee.blogspot.com; (E) http://termitesolutions.com.au; (F) Michelle Au, http://2.bp.blogspot.com

- Stack packaged foods in orderly rows on pallets so they can be easily inspected in warehouses, restaurants, schools, and food plants (Figure 11.7 B). There should be a minimum of 18 inches (46 cm) off the ground and the same distance from side walls.
- Place pallets in aisles for cleaning and inspection. Painting a 12-inch (30 cm) yellow or white band on the floor in commercial storage areas permits easier detection of rodent droppings.
- Eliminate clutter in rooms, closets, and other interior areas of a structure (Figure 11.7 C).
- Re-organize items in storage at least once a year. Donate or eliminate items that are not used in the previous year.
- Remove plant groundcovers (e.g. low-lying shrubs, vines) near buildings. A visual inspection zone of 2 feet (0.6 m) is recommended.
- Remove high grass, weeds, wood piles, old equipment, and construction debris adjacent to a structure (Figure 11.7 D).
- Renovate or destroy abandoned buildings (Figure 11.7 E).
- Trim back tree branches at least 6 feet (2 m) away from the building. No branches should be allowed to extend over the roof of a structure (Figure 11.7 F).
- Trim back shrubs at least 2 feet (0.6 m) away from the building.

EXCLUSION

Long term, the most successful form of rodent control is to build them out. Also called rodent proofing, this technique makes it impossible for rats and mice to enter a structure or a specific area within a building. Mice and rats can squeeze through small openings and jump vertically to amazing heights based on their body size. Look at possible access points at least 3 feet (1 m) above and below ground level for mice and Norway rats, while on the roof and along eaves for roof rats.

Suggestions for repairs to a structure to exclude rodents include the following.

- Seal spaces around doors to ensure a tight fit, especially between the door and floor threshold.
- Check door (personnel entry and overhead doors) brushes or rubber seals and/or thresholds quarterly and replace as needed. For swinging or sliding doors, seals can be heavy-duty brush, vinyl, or rubber strips. For larger overhead doors, install compression seals.
- Seal cracks, holes, and other unneeded openings in building foundations and exterior walls (Figures 11.8 A, B).
- Block openings around water, sewer, and gas pipes, and around dryer vents, telephone and electric lines where these penetrate walls.
- Use permanent sealants (e.g., cement, sheet metal, hardware cloth) whenever possible.
- Screen air vents and chimney openings.

Figure 11.7. (A) Overflowing, open garbage dumpster; (B) Ordered, clean food warehouse; (C) Messy food pantry; (D) Removal of construction debris needed; (E) Abandoned house; (F) Tree too close to building.
Image credit: (A) www.ripoffreport.com; (B) www.warehouse-systems.co.uk; (C) www.nerdfamilyfood.com; (D) www.artsjunkremoval.com; (E) http://globalgreen.org; (F) Trees of Lycoming, IN; www.mapsofpa.com

- Screen floor drains and make sure covers fit tightly.
- Fit windows and screens tightly.
- Install rat guards in the water seals of toilet bowls (Figure 11.8 C). The rat guard is a 30-inch (75-cm) long, 8-inch (20-cm) diameter piece of pipe that is cut into the vertical 4-inch (10-cm) sewer pipe. A rat can climb inside the vertical 4-inch pipe but cannot span the 8-inch rat guard.
- Space the connecting hardware for utility lines that run along the outside of a building far enough apart that they do not form a ladder for rodents to follow into the building.

Because rodents can gnaw through all types of building materials, the following table (Table 11.1) lists materials that can be used to build rodents out.

Table 11.1. Materials used for rodent proofing building structures

MATERIAL	SPECIFICATIONS
Galvanized sheet metal	25 gauge or heavier
Galvanized or rust-proof expanded metal	28 gauge or heavier; mesh opening no larger than ¼ inch (6 mm)
Perforated metal	24 gauge or heavier; no perforations larger than ¼ inch (6 mm)
Galvanized or rust-proof hardware cloth	19 gauge or heavier; no opening greater than ¼ inch (6 mm)
Cement mortar	1:3 mixture or richer
Concrete	1:2:4 mixture or richer
Brick	Regular size (3¾ inches; 9.5 cm) with mortared joints
Metal kick plate for door	12 inches (30 cm)

If a foundation cannot be sealed, consider building a curtain wall around the foundation. The wall can be made of hardware cloth (19 gauge or heavier) that extends 3 feet (0.9 m) straight down into the soil. Alternatively, the hardware cloth can be "L-shaped" with the long part of the material going straight down and the lower part turning out away from the building. A rat that digs down would be diverted by the L turn away from the foundation.

You should also check roof areas (e.g., roofing, flashing, eaves, fascia boards) for signs of rodent entry. Concentrate your inspections where utility lines enter a building and where tree, shrub, or vine branches come near to the building. Repair or replace suspect areas (Figure 11.8 D).

A checklist is provided in Tables 11.2 and 11.3 to assist you in excluding rodents from your building.

Trapping

Trapping can be a very effective form of rodent control, especially if you are dealing with mice. Some advantages of trapping include the following.

- Traps are non-toxic and can be used in sensitive accounts.
- Their effects are most notable with a small rodent population.
- Results can be seen directly.
- They trap bait-shy rodents.
- Trapped mice pinpoint areas of activity.
- Dead rodents can be disposed of easily, thus eliminating odor problems.

The primary disadvantages are the time and labor required to put out and maintain traps with severe rodent infestations.

Traps should be checked daily and dead rodents disposed of in plastic bags. Protective, disposable gloves (e.g., neoprene, nitrile) should be worn when handling rodent carcasses to prevent any chance of disease spread. Decomposing rodents attract flies, dermestid beetles, and other insects, which can lead to additional problems if not removed in a timely fashion. Records should be kept indicating where and when rodents were trapped so management plans can be modified as needed.

SNAP TRAPS

This type of rodent trap is readily recognized, widely available, and easy to use. The spring-powered trap relies on a sensitive trigger to release the arching arm and kill the rodent. A smaller version is used for mice, while the larger trap is used for rats. Successful traps, once reset, are more effective at trapping rodents compared to new or cleaned traps. Snap traps should be oriented perpendicular to the wall, with the trigger end against the vertical surface.

Table 11.2. Rodent IPM Checklist for Exterior Areas.*

Place a check mark under "Yes" or "No" for each item. When finished, make corrections to the facility for the "Yes" answers to improve rodent management.

ITEM	NO	YES
General Sanitation Evaluation		
• Trash areas unkempt, providing rodents food		
• Materials stacked and stored against foundation		
• Clutter and trash around foundation areas		
• Exterior dog pens unkempt (feces, old food, weeds)		
• Bird and wildlife feeders overfilled or with seed residues		
Rodent Proofing and Exclusion		
Roof and Roofing Materials		
• Soft or spongy areas of deck noted		
• Shingles damaged, missing		
• Vinyl or rubber roofing with gaps in seals around edges or at seams		
• Evidence of water pooling/ inadequate drainage		
• Gutters leaking or clogged		
• Gutters holding water due to improper pitch		
• Kitchen vent unscreened		
• Bathroom vent(s) unscreened		
Chimneys		
• Rain cap/ spark arrestor absent or in need of repair		
• Missing bricks or mortar		
• Holes or large gaps in other materials		
• Flashing absent or present and showing signs of deterioration or leaking		
• Evidence of animal activity		
Eaves, Fascia, Soffit, and Frieze Boards		
• Moisture damage behind/under gutters		
• Soffit vents unscreened		
• Presence of ¼ inch (6 mm) gaps between siding and frieze or soffit boards		
• Presence of smudge marks from rodents getting into attic through gaps		
• Attic vent(s) unscreened		
Proximity of Trees, Shrubs, and Other Vegetation		
• Tree limbs less than 6 feet (2 m) back from roof edge		
• Shrubs less than 18 inches (45.7 cm) from building walls		
• Vines climbing on walls		
Plumbing Soil Stacks		
• Screen missing		
• Flashing absent or present and showing signs of deterioration/leaking		

* Modified from Rodent Control by R.M. Corrigan. 2001. *Rodent Control: A Practical Guide for Pest Management Professionals.* GIE Media, Cleveland, Ohio. 355 pages.

Table 11.2. Rodent IPM Checklist for Exterior Areas* (continued)

Place a check mark under "Yes" or "No" for each item. When finished, make corrections to the facility for the "Yes" answers to improve rodent management.

ITEM	NO	YES
Rodent Proofing and Exclusion		
Foundation Areas		
• Gaps greater than ¼ inch (6 mm) at siding-foundation junction		
• Holes or crevices in foundation greater than ¼ inch (6 mm)		
• Vertical or horizontal cracks in foundation		
• Foundation vent(s) blocked by plants, debris		
• Foundation vent(s) not screened		
Utility Lines and Attachments		
• Dryer vent unscreened		
• Dryer vent with unsealed gaps		
• A/C supply lines with unsealed gaps		
• Natural gas lines with unsealed gaps		
• Electrical lines with unsealed gaps		
• Telephone lines with unsealed gaps		
• Cable TV lines with unsealed gaps		
Doors		
• Light visible from inside looking out closed personnel door(s)–sides, bottom		
• Threshold seal absent or in need of repair closed personnel door(s)		
• Light visible from inside looking out closed overhead door(s)–sides, bottom		
• Brush strips or compression seals absent on bottom of overhead door(s)		
• Gaps present at molding-siding junction, allowing rodent entry		
• Door propped open for ventilation		
• Screens on door in need of repair/replacement		
Basement Windows		
• Window(s) cracked or missing		
• Window seals in need of repair		
• Window(s) unscreened		
Porches, Decks, and Outbuildings		
• Evidence of animal nesting/harborage		

* Modified from Rodent Control by R.M. Corrigan. 2001. *Rodent Control: A Practical Guide for Pest Management Professionals.* GIE Media, Cleveland, Ohio. 355 pages.

Table 11.3. Rodent IPM Checklist for Interior Areas.*

Place a check mark under "Yes" or "No" for each item. When finished, make corrections to the facility for the "Yes" answers to improve rodent management.

ITEM	NO	YES
Attic		
• Vents unscreened or screens in need of repair		
• Evidence of roof leaking (especially around chimney, vents, etc. that penetrate the roof and in roofline valleys)		
• Area cluttered with no easy access to perimeter, corners		
• Evidence of animal activity (droppings, nests, dead or live animals)		
Living Spaces		
• Rooms cluttered, unkempt		
• Kitchen counters, floors unclean		
• Unwashed dishes left out overnight		
• Food scraps left out overnight		
• Unemptied trash cans present		
• Closets cluttered		
• Plumbing penetration in walls unsealed (kitchen, bathrooms, utility room)		
• Electrical penetrations unsealed (kitchen, bath, laundry, utility, garage)		
• Cracks/crevices in walls, between cabinets and walls or floors		
• Cracks in concrete in garage, steps to house		
• Pet food left out overnight		
• Appliances not moved regularly for cleaning		
Garage, Basement, Crawl Space		
• Area cluttered with no easy access to perimeter, corners		
• Windows/vents not tight fitting		
• Windows/vents not framed with treated wood		
• Windows/vents unscreened		
• Floor drains unscreened with loose-fitting cover		
• Exterior doors without weather stripping, do not seal well		
• Presence of ¼ inch (6 mm) gaps in walls, or wall to house junction		
• Presence of smudge marks from rodents getting into areas through gaps		
• Evidence of rodent activity on sill plate (droppings), especially corners		
• Evidence of rodent activity in basement corners, especially behind clutter and any shelving or furniture		

* Modified from Rodent Control by R.M. Corrigan. 2001. *Rodent Control: A Practical Guide for Pest Management Professionals.* GIE Media, Cleveland, Ohio. 355 pages.

Traps must be set in the right places, in high numbers, and in the right position or rodents will miss them entirely. Here are some factors to keep in mind when trapping rats and mice.

- Set traps with bait (if food is in short supply) or without bait if food is plentiful.
- Bait traps with items that are more attractive than food sources that are readily available. When there are many rodents present, offer different types of baits. Secure loose baits with string or floss.
  - Good mouse baits include small amounts of peanut butter, bacon, chocolate, gumdrops, nutmeats, vanilla extract, potato chips, snack cracker, and nesting materials (e.g., cotton ball, floss, strip of paper).
  - Baits for Norway rats include peanut butter, hot dog slices, bacon, and nutmeats.
- Sprinkle oatmeal or other cereals around the traps to make them more attractive. Alternatively, dust the floor with talcum powder near the traps to show if rodents are traveling nearby.
- Take advantage of a rodent's behavior when trapping.
  - For rats, leave the traps unset for a few days to reduce the animal's fear of new objects in their environment.
  - For mice, rearrange a space or storage area before placing traps as they are curious and will explore the "new" area.
- Move boxes and other objects around to create narrow runways for trap placement.
- Set unbaited traps along runways, along walls, behind objects, or in dark corners where the rat travels through a narrow opening.
- When runways are located on rafters and pipes, set the expanded trigger models directly across these structures, fastening them to pipes with wire, heavy rubber bands, or hose clamps, and to rafters with nails.
- Place snap traps where signs of rodent activity are observed (Figure 11.8 E). For mice, this means sites with large numbers of droppings where the animals congregate.
- Extend the trapping area in three dimensions from an area with active signs. Consider areas above or below food supplies, such as in suspended ceilings, attics, inside pipe runs, above walk-in coolers, in floor voids, under coolers, and in processing equipment.
- Use enough traps. More traps are better than fewer trap numbers.
  - Use 10 to 20 for a house; 100 for a small warehouse.
  - Place 5 to 10 traps in an active corner of a room.
  - Avoid placing traps at equal distances around the interior perimeter even though the traps may look nice/orderly to the person placing them. Concentrating on active locations will result in a greater numbers of rodents trapped.
  - In a rodent-active area, place traps for mice less than 10 feet (3 m) apart and 15 feet (4.5 m) for rats.

  - Consider the jumping behavior of rodents when setting traps. A rodent can leap over one but will be caught in another trap.
    - Place 2 traps side by side with triggers next to wall for mice or 3 traps side by side for rats (Figure 11.8 F).
    - Use 2 traps end to end along wall with triggers facing outward.
- Set traps in a shallow pan of meal, sawdust, or grain when only a few rats remain and these have resisted capture to this point.
- Avoid spraying snap traps with an insecticide or storing traps with pest control application equipment. These odors will be absorbed on the traps and will repel rats.
- Inspect traps frequently to remove dead rodents and change old bait.
- Warped traps should be replaced since this is one way trap-shy mice are produced (rocker arm misses the mouse and scares it away).
- Avoid handling/petting a dog or cat before setting traps because these odors are repellent to rodents.

MULTIPLE-CATCH TRAPS

Multiple-catch traps are designed for mice (Figures 11.8 G, H). The curiosity of a mouse attracts it into the trap's small opening. Once inside the entryway, either a one-way door or a wind-up mechanism puts the mouse into the trap's holding area. Another type of multiple-catch trap operates on the principle of a trap door. Mice usually die from "capture stress" (combination of confinement and food and water deprivation) or hypothermia (loss of body heat). You may encounter live mice when checking traps.

There are several advantages for using multiple-catch traps:

- Very efficient, catching up to 15 mice in a single setting
- Easy to set and place
- Relatively safe for children and pets
- No baits required
- Sturdy and can withstand casual abuse
- Usable in harsh environments (indoors or outside)
- Can be cleaned
- Can place entire trap in bucket of soapy water or in carbon dioxide chamber to kill any live mice

Actions to consider when using multiple-catch traps:

- Check traps regularly and make sure mechanisms are functioning properly.
- Place the traps directly against a wall or object with the opening parallel to the runway, or point the entryway toward the wall and leave a 2-inch (5 cm) space between the wall and the trap.
- Consider placing a glue board on top of the trap, as mice will sometimes jump on the trap to investigate it.
- For maintenance trapping, position the traps at high risk areas and potential mouse entry points (e.g., loading docks, near utility lines, at doorways).

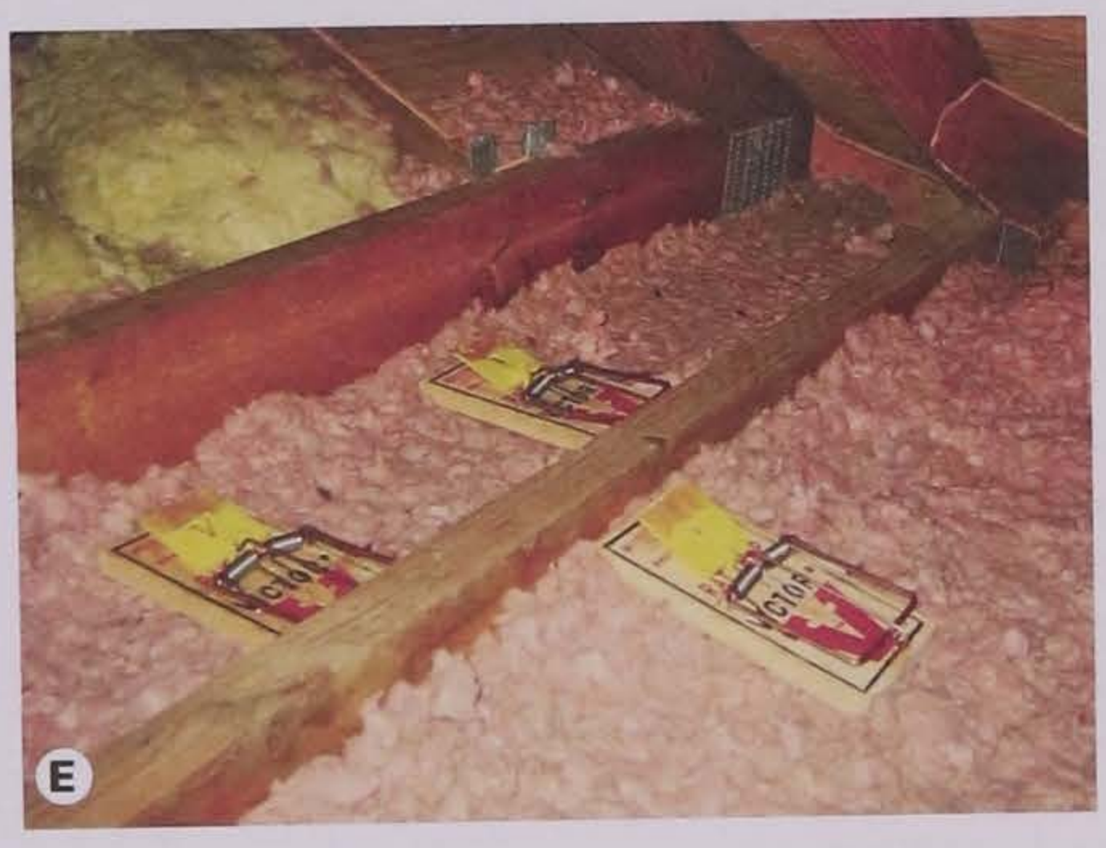


Figure 11.8. (A) Checking for rodent entry sites; (B) Plugging rodent entry sites; (C) Rat sewer excluder; (D) Repairing eaves to exclude rodents; (E) Placement of snap traps along runway; (F) Placing snap traps side by side to catch mice. Image credit: (A) www.absolutebusinesses.co.uk; (B) www.americanpest.net; (C) Stephen Vantassel, http://wildlifecontrolconsultant.com; (D) http://rodentsolutioninc.com; (E) www.wildlife.pro; (F) Tom Barnes, http://2.bp.blogspot.com

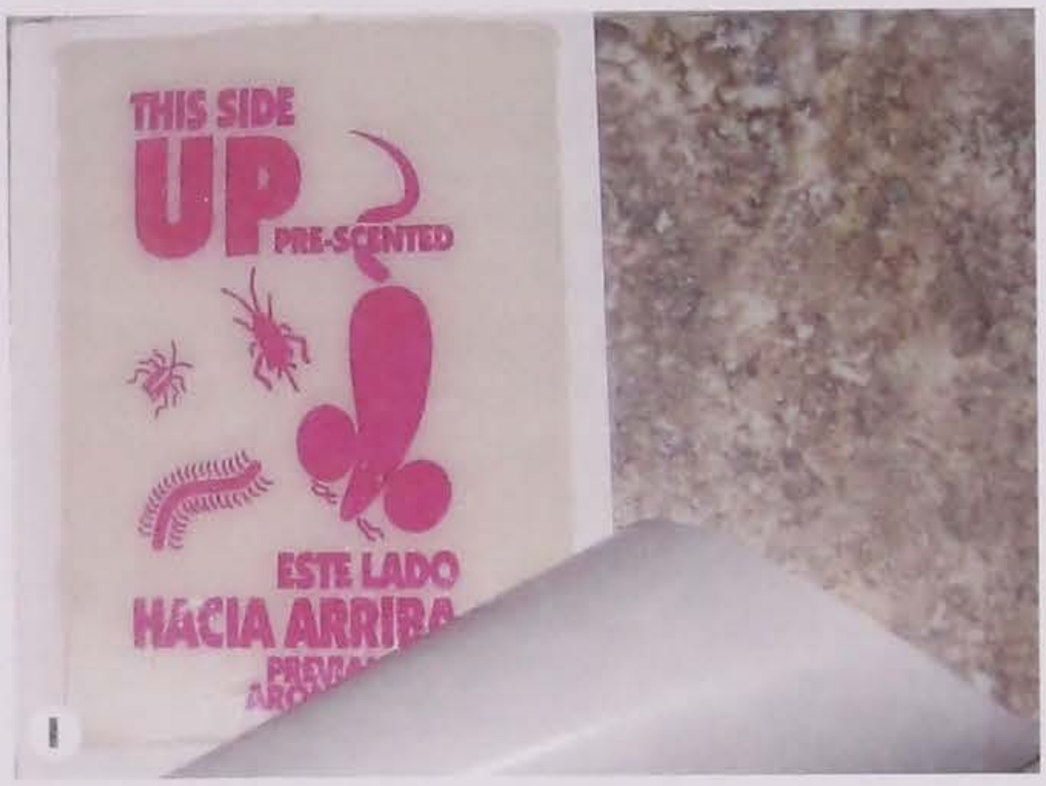


Figure 11.8. (G) Low-profile multi-catch mouse trap; (H) High-profile multi-catch mouse trap; (I) Example of a glue board; (J) Placement of glue board in mouse runway; (K) Bait box showing rodenticide bait on rods; (L) Example of rodenticide placement. Image credit: (G) www.2102.net; (H) http://media.qcsupply.com; (I) www.m1288.sgded.com; (J) http://peststopsg.com; (K) www.gardexinc.com/; (L) http://site.palemale.com

GLUE BOARDS

Another way to trap rodents is with glue boards that use a sticky material spread over cardboard (Figure 11.8 I). The rodent becomes entangled in the glue when it runs over the board.

Advantages of glue boards include:

- Glue board is the preferred trap in homes and other sensitive accounts.
- Trapped rodent and glue board can be discarded in the trash.
- Glue board does not need to be baited to be effective.
- Mineral oil or vegetable oil will free the paw of a curious pet or the hand of a person temporarily trapped in the glue.
- Two sizes are readily available, a smaller one for mice and a larger one for rats. However, glue boards can be custom made to fit the space available.
- Some glue boards are used inside multiple-catch traps.
- Ectoparasites (e.g., fleas, ticks, lice) have an excellent chance of being trapped in the glue, greatly reducing public health concerns.

Disadvantages of using glue boards include:

- Glue boards are less effective in areas that are especially wet or dusty when the trap is unprotected.
- Glue can run off the cardboard in extremely hot weather.
- Glue hardens to an ineffective state in cold weather or sites.
- Captured animals die of suffocation; some clients will not want you to use the devices to service their accounts.

Suggestions for using glue boards include:

- Place them in the same locations as you would snap traps.
- Place them lengthwise, flush against the wall, box, or other object that edges a runway (Figure 11.8 J).
- Avoid placing glue boards directly over food products or food preparation areas.
- Secure the glue board with a thin wire so a rat can't drag it away.
- Install a glue board in a bait station if:
  - children or pets could come in contact with the trap,
  - people might get upset observing a struggling rodent, or
  - the area has excessive dust or moisture.
- Add a few pieces of dry grain or seeds to the middle of the board. Do not use oily bait (e.g., peanut butter) because the oils will inactivate the glue and the trap will not hold a rodent.
- Check glue boards frequently and dispose of rodents when found.

Rodenticide Use

A rodenticide is a pesticide designed to kill rodents. Their toxic effects are not limited to rodents; they can harm people or other animals as well. You must know and understand the use of rodenticides and strictly follow label directions. The proper use of any pesticide is your top priority if a pesticide is used.

There are two major types of rodenticides, set apart by their toxic action on the rodent:

- Anticoagulants—**Anticoagulants** act by damaging blood vessels and inhibiting blood-clotting mechanisms. The poisoned rodent dies from internal bleeding. The process takes several days and does not cause pain to the rodent. Ingesting one dose of some active ingredients is sufficient, while multiple feedings are needed for other active ingredients. Examples of anticoagulant active ingredients include: brodifacoum, bromadiolone, chlorophacinone, difethialone, difenacoum, diphacinone and warfarin.
- Non-anticoagulants—these toxicants have various modes of action but do not interfere with the animal's ability to clot blood. Some products are effective after a single feeding while others require multiple feedings. Examples of non-anticoagulant active ingredients include:
  - Bromethalin—kills rodents by disrupting energy production within body cells. The resulting fluid buildup, especially in the brain and spinal cord, leads to a decrease in nerve impulses and eventual paralysis and death. Slow action does not promote bait shyness and after consuming a lethal dose the rodent dies.
  - Cholecalciferol—this active ingredient is a concentrated form of vitamin D3. It causes the body to release too much calcium from the bones into the blood stream and the rodent dies from heart failure.
  - Zinc phosphide—a toxin with quick activity, this chemical reacts with water and acid in the rodent stomach to produce poisonous phosphine gas. Death results from heart paralysis, as well as gastrointestinal and liver damage. Zinc phosphide has a distinct garlic odor that is attractive to rodents.

RODENTICIDE FORMULATIONS

DETECTION BLOCKS

Although they do not contain a rodenticide active ingredient, detection blocks are available to determine if rodents are present in a location and to get a general sense of the number and type of rodents. Some detection blocks are formulated with luminous biomarkers that fluoresce green under ultraviolet light. These nontoxic blocks can then be replaced with their toxic counterparts to begin rodent management.

FOOD BAITS

Most rodenticides are formulated as food-based baits containing seeds or grain to attract the rodents. Commercial baits are available in place packs (bait within a small paper or cellophane sack), treated seed and grain, and paraffin pellets, cylinders, or blocks.

One serious disadvantage of food bait is that rodents can carry off pieces; this bait translocation results from normal hoarding behavior. Baits that were carefully placed out of the reach of children and pets may end up out in the open. This presents exposure risks to your customers and liability risks to you. The risk of bait translocation may dictate your choice of formulation.

A tamper-resistant bait box is designed so a child or pet (especially dogs) cannot get the bait inside, but the rodent can. These boxes are constructed of metal or non-crushable plastic, are lockable, and are usually secured to the floor, wall, or ground. In addition, they have a specific internal design for confining bait, such as a wire rod to hold bait blocks or cylinders (Figure 11.8 K). You should label each bait station with a precautionary statement from the product label and company contact information.

Rodenticide baits must be used within 100 feet of man-made structures that are constructed in a manner so as to be vulnerable to commensal rodent invasions and/or harboring or attracting rodent infestations. Some bait can be applied to burrows beyond 100 feet.

Suggestions for food baiting include the following.

- Use small bait stations for mice and larger ones for rats.
- Put out enough bait; make as many placements as practical. Incomplete baiting can lead to bait shyness and interfere with control efforts.
- Place bait stations in active locations (e.g., runways, where fresh fecal pellets are found) and to intercept incoming rodents (e.g., on both sides of busy personnel and overhead doors) (Figure 11.8 L).
- Keep the distance between bait boxes 10 to 20 feet (3 to 6 m) for mice and 15 to 50 feet (4.5 to 15 m) for rats.
- Check boxes periodically to ensure bait freshness and acceptance.
- Limit burrow baiting to sites where packs can be placed 6 inches (15 cm) or more into active rat burrows.
- Do not broadcast bait on the ground in rodent infested areas.
- Use **paraffinized** baits if the bait will be regularly exposed to moisture.
- Keep a station in place as long as rodents are taking the bait; the animals now consider it to be a part of their normal surroundings.
- Number each bait station and make a map as to their location on the property. In addition to speeding up service activities, the map will give you information on rodent activity and possible entry sites.

WATER BAITS

In some instances, liquid (water) baits are more successful than dry baits. Rats need a daily ration of water to survive. Although mice usually obtain their water requirements directly from their food sources, they will freely drink from a water bait station if it is placed in their home range. Water baits are particularly effective in sites where water or food with high moisture content is scarce, such as a dry goods warehouse. Diphacinone is a common active ingredient for water baits.

Increased installation and service times, risk of spills, and restriction to environments above freezing temperatures are disadvantages of using water baits. Use this formulation only where no other animals or children can get to them.

TRACKING POWDERS

Tracking powders combine the active ingredient of talc or finely ground clay. The material is placed in rodent runways or active burrows. When the animal travels across the powder, some of it sticks to their feet, fur, and tail. The rodent will swallow the powder during grooming. Because small amounts of powder are consumed, the concentration of rodenticide is higher than in baits. Chlorophacinone, diphacinone, and zinc phosphide are examples of active ingredients formulated as tracking powders.

Placement of tracking powders to minimize nontarget exposure is very important. Keep in mind that the rodent will carry the powder on its body wherever it travels, including food preparation surfaces or on stored foods. Tracking powders are usually not recommended for use in and around homes because of the hazard to children and pets.

Some suggestions for using tracking powder include the following.

- It is best to apply heavier than an insecticide but never deeper than ⅛ inch (3 mm).
- Best application sites are inside dry, infested wall voids; around rub marks; along pipe and conduit runs; active, discrete runways; and in dry burrows (when permitted by the product label).
- Placement in bait stations, in PVC pipe, cardboard tubes, or any other small dark shelter area will minimize nontarget access.
- Application equipment could include a hand duster or similar device that is properly labeled.
- Tracking powders should not be used in suspended ceilings, around air ventilation areas, or near food or food preparation areas.

FUMIGANTS

Certain rodenticides are also formulated as poisonous gases (fumigants). The most common use of these products is for burrow gassing. Although this is a fast and effective way to control burrowing rodents (e.g., Norway rats), these products can be extremely dangerous if used improperly. Persons doing fumigation work must become certified in Category 7C, Fumigation. Preparation for the certification exam should involve reading, "Fumigation," Iowa Commercial Pesticide Applicator Manual, CS 27.

Secondary Hazards

Secondary hazard refers to the risk that a nontarget animal will consume rodents that have been poisoned by rodenticides. These routes of exposure are a concern because rodenticides are toxic to nontarget animals that readily consume bait and/or rodents. Possible animals impacted are pets, livestock, zoo animals, raptors (e.g., owls, hawks, eagles), and other wildlife.

Rodenticide secondary hazards can be classified as:

1. Primary poisoning—when an animal directly consumes a rodenticide. This usually occurs when bait is placed in an unprotected location.

2. Secondary poisoning—when one animal is poisoned after consuming the flesh of another animal that has digested the poison.

3. Secondary ingestion—when one animal (e.g., cat) consumes a rodent that still has undigested bait in its gut or mouth. Technically, the animal is directly (although unknowingly) consuming the rodenticide bait.

In theory, secondary ingestion presents a higher risk of poisoning to nontargets because more of the rodenticide is consumed. The chance of an animal (e.g., dog, cat) being poisoned by consuming exposed rodents is extremely small. For one thing, the amount of toxicant needed to kill a mouse or rat is much smaller than the amount required to poison a cat or dog. The unsuspecting animal would have to consume a large number of exposed rodents to actually ingest a toxic dose of the rodenticide. The fact that many mice or rats poisoned die in harborages or other inaccessible areas further decreases the chances that a dog or cat will get enough rodenticide to be poisoned.

A bigger concern is exposure of wildlife to rodenticide. There is speculation that drastic drops in barn owl populations in the eastern United States may be related to rodenticide use. The New York State Wildlife Pathology Lab has diagnosed rodenticide (especially brodifacoum) poisoning in birds of prey. These raptors weigh less than household pets and they can obtain a toxic dose with a much smaller exposure to rodenticide.

Chapter 12
Other Vertebrate Pests

Overview

As a PMP, you may get involved with the management of wildlife that invades structures. Examples of such vertebrate pests include birds, bats, and squirrels.

Most states have laws, licensures, and/or certifications regarding nuisance wildlife control. Federal endangered and threatened species laws may need to be reviewed for certain protected species that can be problematic. It is your responsibility to be familiar with these regulations; they do constitute an additional set of rules (beyond the pesticide label and pesticide certification) in which you must function.

Birds

Birds provide enjoyment and recreation while enhancing the quality of life. Bird watching as a sport and recreational activity involves millions of people. For this reason, laws, regulations, and public opinion protect birds.

Birds can become pests when they feed on crops (Figure 12.1); create health hazards; roost in large numbers on buildings; deface buildings, sidewalks, and cars with droppings (Figure 12.2 I); plug downspouts and air vents with nests; contaminate food; or otherwise create a nuisance. Bird ectoparasites (e.g., mites, lice, swallow bugs) can invade living areas and bite humans. Birds can also transmit cryptococcosis and histoplasmosis, which are serious, systemic, fungal infections acquired by inhaling airborne spores that grow in bird droppings. No particular species can be flatly categorized as beneficial or harmful; these designations depend on time, location, and activity.

Figure 12.1. Nuisance birds. Image credit: photogirl723, www.pxleyes.com

Learning Objectives

After studying this chapter, you should be able to

- Define avicide
- Identify three common signs of birds in/on a structure
- Tell the difference between feeding, loafing, and roosting sites of feral pigeons
- List common starling and house sparrow:
  - Nesting sites
  - Food preferences
- Explain why successful bird control involves several control methods
- Discuss the daily and seasonal activity of bats
- Distinguish between the little brown bat and the big brown bat
- State the best method to control bats in a structure
- Name five common entry sites for squirrels entering a structure
- State how rat glue boards can assist in managing snakes
- Identify the damage to a structure that can be caused by raccoons
- Tell how the opossum can be a household pest
- Discuss the human health concerns of: birds, bats, raccoons, skunks
- Outline four things a client can do to eliminate conducive conditions for: birds, snakes, skunks, raccoons, opossums
- Give examples of vertebrate pests that can be legally trapped
- Name three repellents used against vertebrate pests

Feral Pigeon (*Columba livia domestica*)

IDENTIFICATION

- Adults are 6 to 10 inches (15 to 25 cm) long.
- Body is plump, beak is short, tail is fan-shaped; body color varies from black, white, gray, and a mixture of these colors (Figure 12.2 A).
- Head bobs when walking; voice is a long, soft, cooing sound.

LIFE CYCLE

- Breeding occurs year round with peaks in spring and summer; one or two eggs laid per brood and 10 young are produced each year.
- Lifespan is highly variable, ranging from 2 to 15 years in urban roosts. Pigeons have lived for 30 years in captivity.

The domestic pigeon is a descendant of the rock doves of Europe, Asia, and Africa. It is believed that it was first brought to this country as a domestic bird in 1606. They have a long history of being raised and kept as domestic birds. Rock doves originally nested in caves, holes, and under overhanging rocks on cliffs; they adapted to window ledges, roofs, eaves, steeples, and other building components in man-made environments.

Feral (wild) pigeons have become the most serious bird pest associated with buildings. They may congregate in flocks of a hundred or more and are considered gregarious animals. Pigeons have separate roosting, **loafing**, and feeding sites.

- Roosting sites are sheltered from the elements and used for nesting, congregating at night, and protection from bad weather.
- Loafing sites will be nearby to roosting sites and are used by inactive birds during the daytime (Figures 12.2 B, C).
- Typical roosting and loafing sites are building roofs and ledges, cooling towers, bridges, and signs (Figure 12.2 D).
- Feeding sites may be near roosting or loafing sites or may be several miles away. Typical feeding sites include parks, town squares, food loading docks, garbage areas, railroad sidings, food plants, and wherever people eat outside. Pigeons prefer flat, smooth surfaces on which to rest while they feed, such as rooftops, open ground, or ledges. Although primarily eating seed and spilled grain, pigeons also feed on garbage, insects, livestock manure, food left by outdoor diners, and food provided by bird enthusiasts.

Pigeons nest on a frail platform of small twigs, straw, and debris in which they make a slight depression. Nests are usually located in protected openings on buildings and structures. The male usually selects the nest site, but both adults actually build the nest with the male often bringing nest materials to the female.

Common Starling (*Sturnus vulgaris*)

IDENTIFICATION

- Adults are 8 to 9 inches (20 to 23 cm) long; average weight is 3 ounces (84 g).
- Body is compact, short, and round; wings are triangular; tail is short and square.
- Color is iridescent blue-black with gold-flecks in summer and white spots in winter; the large, spear-like bill is yellow (summer) or dark (winter); young birds are grayish (Figures 12.2 E, F).

LIFE CYCLE

- Flight is direct and swift, not rising and falling like many blackbirds.
- Two broods are produced per year, with 4 to 7 young per brood.

European starlings were introduced into the United States in 1890, when 60 birds were brought into New York City. They have since expanded their range across North America and number in the hundreds of millions.

In natural settings, starlings nest in holes or cavities in trees or rocks. In urban areas, they nest on buildings, in birdhouses, on power stations and water towers, and on other structures. Both parents build the nest, incubate the eggs, and feed the young. Nests are made of stiff, fibrous material lined with fine grass or other soft material.

Starlings migrate in some parts of their range. As cold weather begins in the autumn, these birds form larger flocks. The major source of food shifts from insects and fruits to grains, seeds, livestock feed, and food in garbage. Roosting areas may shift from rural and suburban settings to cities and towns (Figures 12.2 G, H). Each day starlings fly up to 30 miles to their feeding sites. One bird ingests 1 ounce (28 g) of food each day.

Leaving their evening roost at sunrise, starlings travel to feeding sites over well-established flight lines. When they return to their roost just before sundown, they do not fly straight to the roost but go to nearby high perches (e.g., trees, power lines, bridges, and towers). The birds are very social at these times and remain on these sites until after sunset, singing and calling to one another.

Starlings are pests because of the high numbers (i.e., thousands) of birds roosting at one site. Droppings at the roost site damage car finishes, tarnish buildings, fall on passersby, and build up in such quantity as to become a health hazard.

Figure 12.2. (A) Feral pigeon; (B) Pigeon roost; (C) Pigeon loafing site; (D) Mess associated with pigeon nesting site; (E) Common starling, summer coloration; (F) Common starling, winter coloration. Image credit: (A) Andrew, http://rambleswithacamera.blogspot.com; (B) www.terrain.net.nz; (C) http://trevorsbirding.com; (D) www.paramountexterminating.com; (E) Mohammed Al-Najar, http://birdwatchinglog.blogspot.com; (F) Mike Watson, http://mikewatsonsdiary.blogspot.com

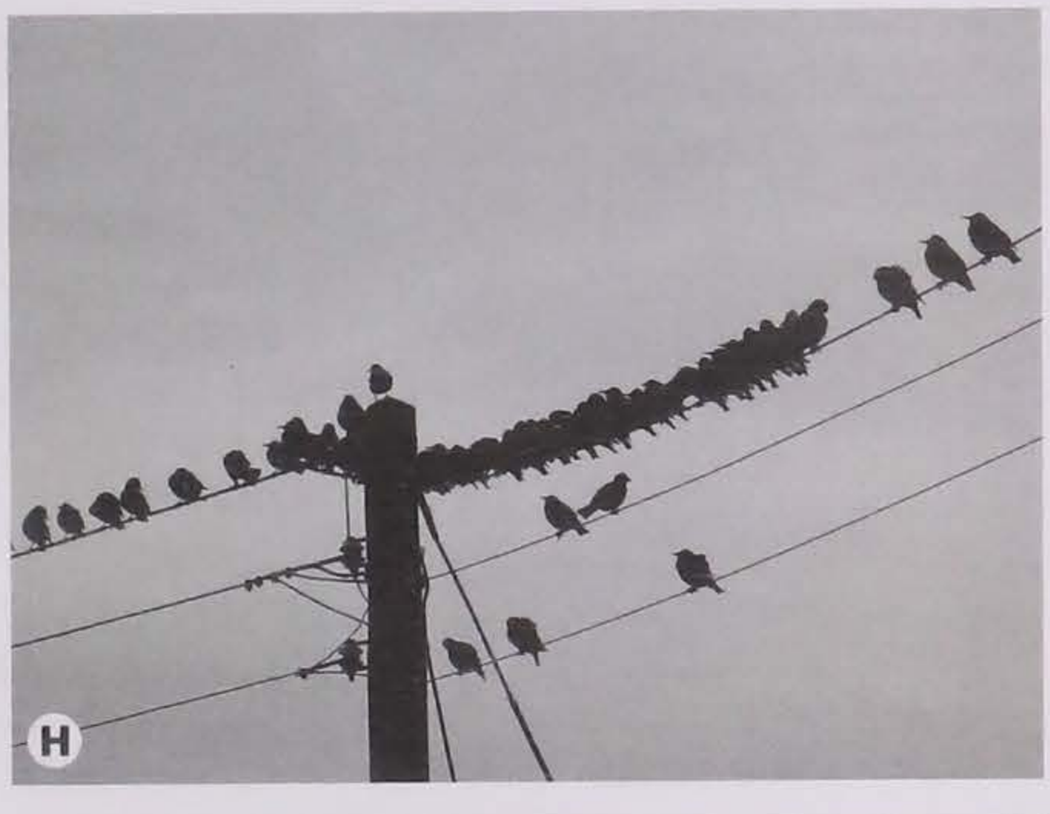


Figure 12.2. (G and H) Starling roosting sites; (I) Bird droppings covering parked car; (J) House sparrow, male; (K) House sparrow, female; (L) Example of house sparrow nest site. Image credit: (G) Ben Moyes, http://2.bp.blogspot.com; (H) Jon Haylett, http://kilchoan.blogspot.com/; (I) www.youngmanblog.com; (J and K) FIR0002, Wikipedia Creative Commons; (L) http://gremlinthecat.blogspot.com

House Sparrow (*Passer domesticus*)

IDENTIFICATION

- Adults are 5 to 6 inches (13 to 15 cm) long (Figures 12.2 J, K).
- Males have a distinctive black throat, white cheeks, a chestnut brown mantle around a gray crown, and chestnut brown upper wing covers; females and young birds are dull brown to gray above, light eye stripe, a gray breast, and generally lack distinctive markings.
- Body is chunky; bill is short and dark.

LIFE CYCLE

- Three broods are produced each year, with 4 to 8 young per brood; breeding is most common from March through August.

The house sparrow, also called the English sparrow, was introduced into the United States in the 1850s. Populations now flourish all over the continental United States except in heavy forests, mountains, and deserts. This bird species seems to prefer human-altered habitats in cities and around farm buildings and houses.

The male house sparrow usually selects the nest site (Figure 12.2 L). Nests are bulky and roofed over. Common sites include trees, shrubs, vines, on building ledges, in trellises, in signs, on light fixtures, under bridges, on power transformers, and in rain gutters. Eggs are incubated for two weeks and the young birds stay in the nest another two weeks.

Sparrows are highly tolerant of human activity, and will not hesitate to set up nests in high traffic areas. They prefer to feed on grain, but will supplement their diet with insects (including Japanese beetles), fruits, seeds, and garbage. It is a bird that is able to eat the Japanese beetle.

This species is gregarious, roosting and feeding together in large flocks. They are territorial, however, during mating and nesting times.

Bird Management Procedures

With very few exceptions, federal laws and regulations protect all birds. Pigeons, starlings, and house sparrows are not directly protected at the federal level but applications of **avicides** (pesticides targeting birds) must be used according to label directions and under FIFRA restrictions, and protect nontarget birds and other animals. State and local regulations may require permits or restrict what actions can be taken against these three pest species.

Be aware of risks when dealing with birds. Dry, dusty droppings may contain fungal spores, which may lead to human disease. Workers cleaning such areas or involved in hand capture of birds should wear approved respirators, appropriate gloves, goggles, and coveralls. Do not eat, smoke, or drink anything until contaminated clothing is removed and you have washed thoroughly.

Inspection

The first step in controlling annoying birds is to conduct a detailed and accurate bird survey. These assessments should be done early in the morning, midday, and again in the evening to correspond to the different activity periods of the birds. Information should be recorded on pest and nontarget bird species. The surveys should answer the following questions.

- What bird species are present?
- How many birds were seen?
- What is the proportion of adults and juveniles?
- Are the birds living as residents or migrants?
- Are birds nesting, feeding, roosting, or loafing at a specific site?
- Where do they eat and drink?
- What is attracting them to the various sites?
- Is the presence of the birds a health risk?
- Are the birds causing property damage?
- If dispersed, where do the birds go?
- If poisoned, where would the birds die?
- What risk exists to nontarget species?
- What state and local regulations impact management activity?
- Could there be public relations problems?
- What control methods appear to be practical?

Habitat Modification

Modifying the habitat for bird management means to limit the food, water, and shelter in the problem sites. Although removal of all food and water for pigeons, starlings, and sparrows is not possible, limiting these necessities in urban sites is important.

- Garbage should be handled in a manner so that none is available to birds.
- Spills of grain or other feed should be avoided and cleaned up immediately if they occur.
- Vacant lots should be mowed to reduce weed seed numbers.
- Nest destruction is ineffective against sparrows and starlings, but pruning trees, shrubs, and vines will sometimes deter birds from roosting.

Exclusion

Building out or preventing birds from roosting or nesting inside or near the doors of a building is good bird management. The best time to do this is before nests or roosts are well established.

Some building designs and conditions lend themselves to bird infestations. Flat ledges, openings in water towers and vents, unscreened windows, and similar attributes make a building an attractive location for nesting, roosting, and loafing. Typical solutions include:

- Replacing broken windows
- Eliminating large crevices and holes

- Adding screens to windows, vents, and rooftop equipment, using ¾ inch (19 mm) galvanized mesh or rustproof wire
- Using plastic or woven bird netting to prevent access to building structures (Figures 12.3 A, B)

Roost Repellents

Roosting repellents force birds to move to other areas. A sticky substance (e.g. polybutene) can be used as roost repellents on ledges, beams, or other areas where birds have been seen roosting. The tackiness of the sticky repellent discourages bird roosting without trapping or poisoning the animals. If the bird picks up enough of the substance, its flight may be affected.

Sticky roost repellents are initially very effective, but their tackiness is lost with time, usually due to accumulation of dirt and debris. Some of these materials do not work under extremely hot or cold temperatures.

A newer roost repellent has the active ingredient methyl anthranilate. It is an irritant sprayed directly on birds and roosts to discourage roosting. This product is applied with a sprayer or fogger. An older irritant/repellent has naphthalene as the active ingredient.

Porcupine wire or plastic spikes can be very effective at repelling birds when installed properly on ledges and inspected periodically to remove debris (Figure 12.3 C).

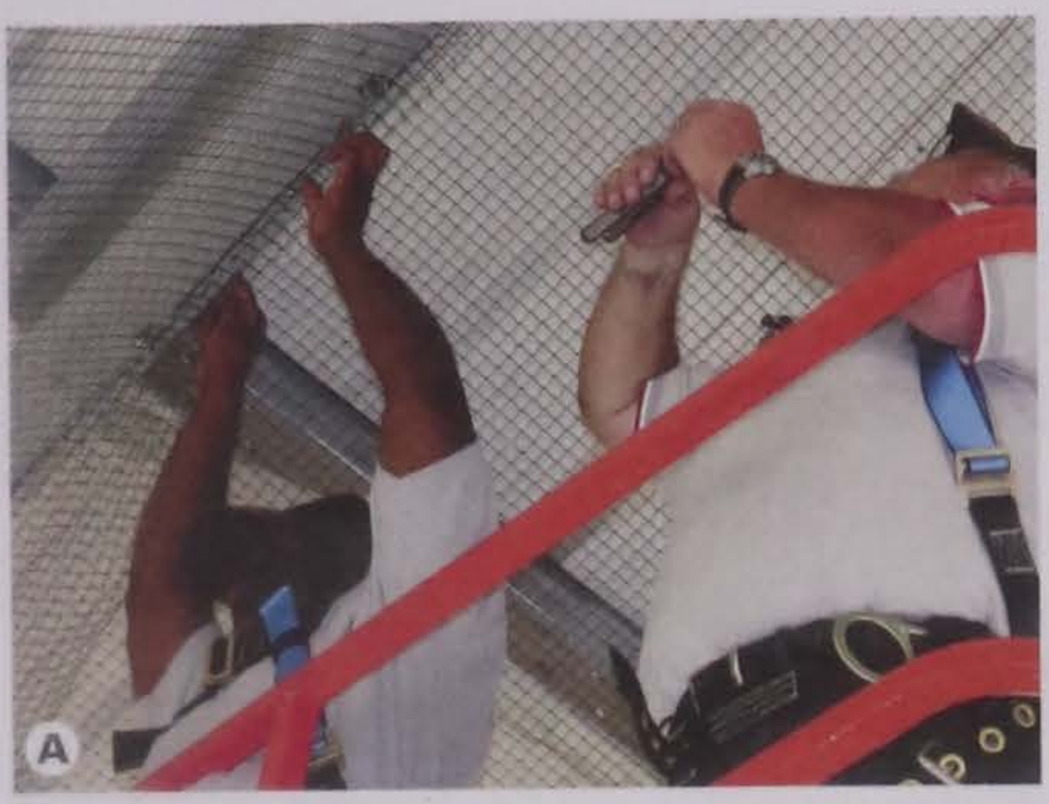
Electric roosting repellents provide a weatherproof system. A cable or track is installed in a position to provide the birds with a desirable perch or roosting place. When birds perch on that track, an electric charge is created that shocks them without killing them. Experienced contractors must install these.

Wood or sheet metal caps can be added to ledges at a 45° angle so that birds can no longer stand on the ledges (Figure 12.3 D).

Other repellents have been used, such as revolving lights, predator mimics (e.g., owl decoys, rubber snakes), noisemakers (e.g., blank guns, fireworks), high frequency sound vibrations, or recorded distress calls (Figure 12.3 E). These devices generally have only a temporary effect, if any, in bird management, and may not be considered cost-effective.

Suppression Techniques

Population reduction techniques must be performed in conjunction with habitat modification and exclusion. People often react more negatively to one dying bird than to accumulating pigeon droppings on sidewalks or potential risks of disease. Pigeons and sparrows are seen as pets rather than pests. The public's perception of bird management operations needs to be considered. Regular communication and teamwork with clients will better prepare them for the various activities and dead birds that result from these activities.



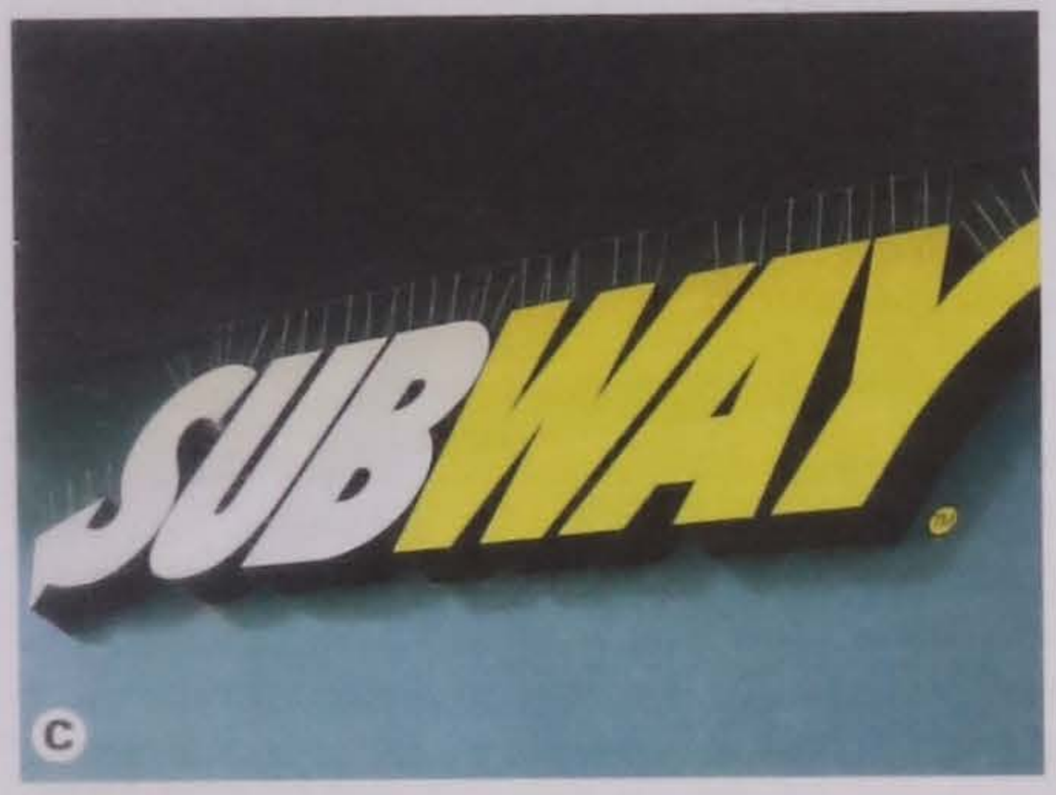


Figure 12.3. (A) Installing netting to exclude birds; (B) Netting prevents bird roosting on figurines; (C) Wire spikes installed on sign; (D) Metal caps installed on ledges; (E) Combination of wire spikes and fake owl to discourage bird roosting/nesting; (F) Trapped pigeons on rooftop. Image credit: (A) http://birdcontrolblog.com; (B and E) Andrew, http://rambleswithacamera.blogspot.com; (C) www.strathearnpestcontrol.co.uk; (D) www.birdbarrier.com; (F) www.unitedwildlife.com

TRAPPING

In the case of pigeons, small populations can often be controlled by capturing them in live traps placed near their roosting, loafing, or feeding sites (Figure 12.3 F). Success of live trapping can be enhanced by pre-baiting with corn or milo for several days before actual trapping begins. Traps should be supplied with plenty of food and water and should be checked daily. Birds that are federally or state protected should be immediately freed if trapped accidentally.

SHOOTING

A possible alternative or supplemental method for eliminating birds is shooting with air-powered pellet guns, if legally allowed. This method is most effective for killing scattered individuals or small flocks.

CHEMICAL MANAGEMENT

The use of avicides in certain situations may be the only means of effective management. These products repel and/or kill birds. Decisions as to the need, type, and method of toxicant use should be made carefully. Poisons may be prohibited or may be too risky to use because of the dangers to humans, pets, or desirable bird species.

TOXIC BAITS

Poison baits with the active ingredient 4-aminopyridine are restricted use products. They are made with whole corn for pigeons, and smaller grains for sparrows and other birds. This avicide is both a repellent and toxin to birds. When eaten by pigeons, starlings, or sparrows, it produces distress reactions (e.g., erratic fluttering, flying into windows or structures, convulsions) in some of the birds. Death of these birds may be caused by the stress or other factors. This reaction frightens the rest of the flock away from the area.

Another avicide used only to control starlings has the active ingredient 3-chloro-p-toluidine. It produces a slower, non-violent death of birds eating the treated grain. Death usually occurs within 24 to 36 hours after feeding.

Pre-monitoring the area to determine the pest bird and nontarget bird populations is a necessary prerequisite to using avicide bait. Also, birds must usually be trained to feed on bait and to establish proper feeding locations. Removal of all the pre-bait corn/small grain before switching to the treated material is important. Good bait acceptance usually results in quicker control of the flock.

CHEMOSTERILANTS

Products with the active ingredient nicarbazin serve as a type of chemosterilant, bringing about pigeon birth control. It interferes with egg hatch success and causes the treated bird population to decline. Products are formulated as ready-to-use baits.

Bats

Bats in the United States are almost always considered beneficial animals. Many bats feed on insects and can consume up to half their body weight in insects at one feeding. It is estimated that a colony of 500 bats could consume 500,000 insects nightly. They will also eat other animals (Figure 12.4 A), and some species eat fruits.

Occasionally, bats will roost in houses, barns, and upper sections of churches and public buildings. The odor from accumulated droppings and urine is unpleasant and will stain ceilings and walls. Noises of bats calling to each other and flying in a structure, as well as the danger of humans being bitten, constitute a health hazard when bats are found inside a man-made structure.

Bats can transmit histoplasmosis and rabies to humans. When working in a bat roost, always wear a respirator and protective clothing.

Bats' role in rabies transmission has been exaggerated since only four percent of bats are infected with rabies. As a precaution, any bat found inside a structure should be considered infected and the following steps taken.

- Wear heavy gloves when handling bats because most bats will try to bite when handled (Figure 12.4 B).
- NEVER handle a bat that is acting in a peculiar manner.
- Capture a bat without crushing its head, if the bat has bitten someone. Refrigerate the animal (don't freeze) and contact the health department for rabies testing.

Habits of Bats

Bats are active in warm weather from late afternoon through early morning (Figure 12.4 C); they are not active during bright daylight. (If you see a bat during the day, it was either dislodged from its roost or it is sick.) When not hunting flying insects, bats rest upside down in dark, secluded areas (e.g., caves, hollow trees, attics of buildings). Bats are able to enter places of refuge through holes as small as ⅜ inch (10 mm).

In the upper Midwest, bats migrate or hibernate when the weather turns cold. In some situations they hibernate in hanging clusters inside buildings. Depending on the species and geographic location, bats breed from late spring to midsummer. Young bats grow rapidly, flying in as few as three weeks after birth.

Species of Bats

Little Brown Bat (*Myotis lucifugus*)

IDENTIFICATION

- Adults are 3.5 to 4.0 inches (8 to 10 cm) long with a wingspan of 8 to 10 inches (20 to 25 cm).
- Adult weight is 0.3 to 0.4 ounces (7 to 10 g). Males are lighter than females.
- Fur is a glossy golden brown to olive brown. Long hairs on each hind foot extend to or just beyond claws on toes (Figure 12.4 D).

The little brown bat is one of several bats in a group called "mouse-eared" bats. This species closely resembles the Indiana bat (*Myotis sodalis*) (Figure 12.4 E), which is a federally threatened species.

LIFE CYCLE

The little brown bat mates in the fall just before hibernation. A single young is born in June or July. This species can fly when it is three weeks old. Summer roosts are abandoned in August or September. Bats will travel as far as 200 miles (322 km) to find a suitable cave for hibernation. Large colonies are sometimes a nuisance and, with the threat of rabies, may not be tolerated in close quarters with humans.

The little brown bat is frequently found in buildings, but will also roost in caves, tree hollows, cliff faces, cavities beneath large rocks, and sometimes inside animal burrows. It prefers to roost near a river, marsh, or lake because its diet consists of mostly aquatic insects (e.g., midges, stoneflies, mayflies, mosquitoes). Each bat may consume as many as 600 mosquitoes per hour; a colony of 100 bats can eat 42 pounds (19.2 kg) of insects in 4 months. Nursery colonies may have from a few to 800 individuals. Little brown bats have a life span up to 34 years.

This species is very heat tolerant and will seek out roosts with high stable temperatures. It has been recorded that these bats can tolerate temperatures up to 129° F, so hot attics are acceptable roosting places for the little brown bat.

Big Brown Bat (*Eptesicus fuscus*)

IDENTIFICATION

- Adults are 4.1 to 4.8 inches (10.5 to 12.3 cm) long with a wingspan of 12 to 13 inches (31 to 33 cm).
- Adults weigh 0.4 to 1.0 ounces (12 to 29 g). Males are lighter than females.
- Fur is long, lustrous, and brown to copper.
- Ear, wing, and tail membranes are black (Figure 12.4 F)

LIFE CYCLE

This bat species will mate in the fall and winter. One or two young are born in late May or early June. Young bats will fly at four weeks of age. The average lifespan of a big brown bat is 2 to 3 years, although males can live 19 years and females 16 years.

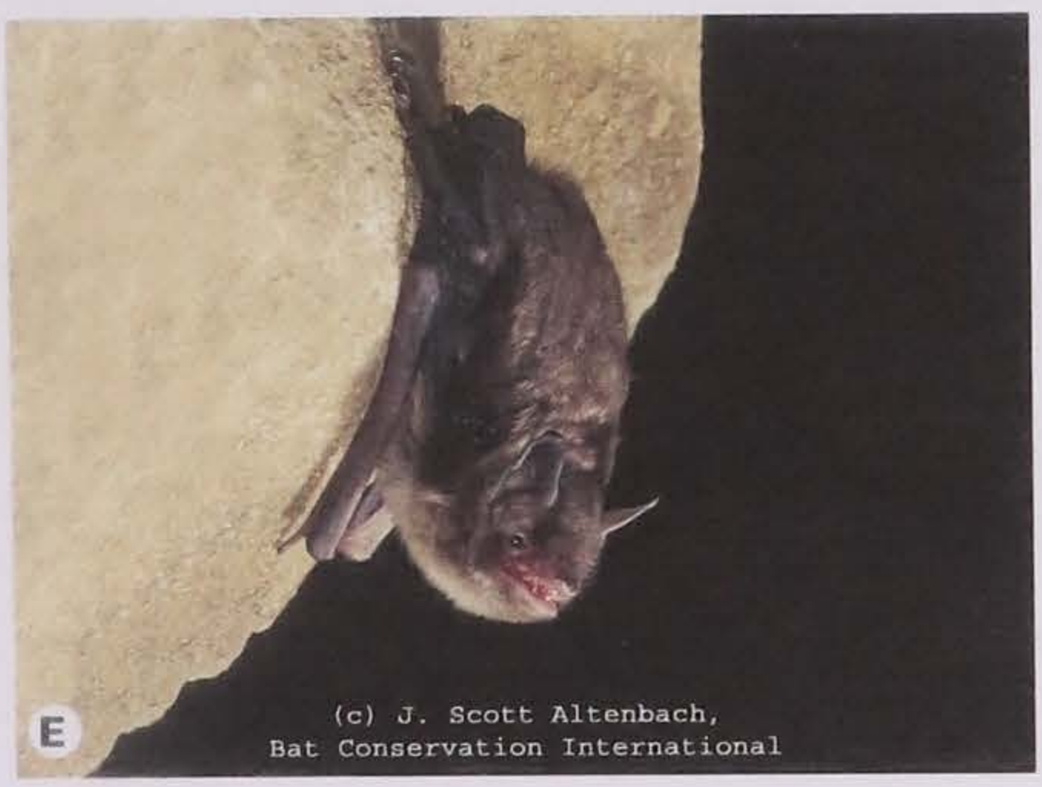


Figure 12.4. (A) Bat eating centipede; (B) Holding bat with gloved hand; (C) Bats in flight; (D) Little brown bat; (E) Indiana bat; (F) Big brown bats in roost. Image credit: (A) http://4.bp.blogspot.com; (B) http://dnfreetime.com; (C) www.brazosport.edu; (D) Luke Ormand, http://3.bp.blogspot.com; (E) J. Scott Altenbach, Bat Conservation International; (F) Merlin D. Tuttle, Bat Conservation International

The big brown bat commonly forms colonies inside buildings. These bats seek out space behind chimneys, inside wall voids, and under eaves to roost. Outside they may roost in tree hollows and under loose bark. Nursery colonies may have from 20 to 300 individuals. Single males often roost alone or in small groups.

The big brown bat is very tolerant of cold temperatures and can survive subzero body temperatures. This ability allows it to hibernate in the walls or other voids of structures as far north as Canada. It is not, however, heat tolerant. When roost temperatures exceed 95° F, it will relocate. Therefore, this bat species is not likely to occupy unventilated attics in summer months.

Buildings can be utilized year round by the big brown bat and this puts them in close association with humans. They are not important mosquito eaters, but prefer to feed on beetles.

The big brown bat may enter a house through open windows and unscreened fireplaces. This bat may appear suddenly during a warm spell in winter, surprising the human occupants of the building.

Management of Bats

Exclusion

The best (and permanent) way of controlling bats is to exclude them from a building; this is often referred to as "bat-proofing" a structure. The goal is to close all openings ¼ inch (6 mm) or larger through which bats may enter or leave (Figure 12.5 A, B). While all potential openings should be addressed, the active openings can be detected by observing the structure at dusk; you will see bats flying out of these active openings.

All openings but one should be sealed with ¼ inch (6 mm) hardware cloth, screening, sheet metal, or steel wool and sealant. Wait three or four days for the bats to adjust to using the remaining opening. Then seal this opening after the bats have exited the roost (Figure 12.5 C) for the evening, usually one-half hour after dark.

In certain situations bat valves can be used. These are placed over the remaining opening and allow bats to leave but not return (Figure 12.5 D).

June and July are peak months for bat complaints. Unfortunately, this is the worst time of year for control because bats are rearing young. Bat-proofing should wait until after mid-August when the young bats can fly.

Plastic bird netting is another material that can be part of bat exclusion. This inexpensive material is easy to work with, tough yet flexible for shaping, and can be fastened over hard-to-seal areas. If needed, the bird netting can be draped over the entire roof to seal multiple openings due to poorly designed construction.

Figure 12.5. (A) Bat entry under roof overhang, note accumulated excrement; (B) Bat entry above window; (C) Bat roost at attic end vent; (D) Bat exclusion device. Image credit: (A) Matthew Grady, www.batguys.com; (B) Verron Federation, http://animaltrappingremoval.com/batremoval/; (C) http://dnfreetime.com; (D) www.aaanimalcontrol.com

Repellents

If bats need to be forced out of a structure before it is bat-proofed, these animals can sometimes be repelled from their roosts. The only chemical registered for this purpose is naphthalene (commonly called moth balls). The crystals or flakes can be spread on attic floors or placed in voids, or an open container can be placed in the bat roosting area. Make sure that the placement does not expose people to the fumes. This treatment is most effective in confined air spaces.

Blasts of air and bright lights have had some success in repelling bats. Ultrasonic devices do not repel bats.

When a single bat finds its way into a home, office, or store, it will usually find its way out again. When it cannot, capture the bat with an insect or fish net, a coffee can, or even a gloved hand. The bat can be taken outside and released.

Tree Squirrels

Adults are small rodent-like animals with long, bushy tails.

IDENTIFICATION

- Adult body length varies from 9 to 28 inches (22.5 to 70 cm); the tail varies from 7.5 to 13 inches (18.8 to 32.5 cm).
- Adult body weight varies from 14 ounces to 2.2 pounds (0.4 to 1 kg).
- Fur color is gray, gray brown, or brown yellow. Underbody is lighter than top of body.

There are many species of tree squirrels that have adapted well to suburban and city life (Figures 12.6 A, B, C). Among them are the fox squirrel (*Sciurus niger*), the Eastern gray squirrel (*Sciurus carolinensis*), and the red squirrel (*Tamasciurus hudsonicus*). Occasionally, squirrels enter buildings and cause damage or disturbance, and must be controlled.

Tree Squirrel Management

Exclusion

The first step in eliminating a squirrel problem in a structure is to find out where the animal(s) are entering. Common points of entry include damaged attic louvers, ventilators, soffits, joints of siding, knot holes, openings where utility pipes or wires enter, chimneys, and flashing.

Heavy gauge ½ inch (13 mm) hardware cloth or sheet metal can be used to seal most openings. Make other suitable repairs as for rat-proofing or bat-proofing.

Figure 12.6. (A) Fox squirrel; (B) Eastern gray squirrel; (C) Red squirrel; (D) Live trap on structure; (E) Squirrel trapped near power lines. Image credit: (A) Ingrid Taylar, Wikipedia Creative Commons; (B) Sage Ross, Wikipedia Creative Commons; (C) Cephas, Wikipedia Creative Commons; (D) http://snikirs.wix.com; (E) http://dallas.wildlifepro.net/

Repellents

There are many repellent products on the market designed to keep squirrels out of attics and other areas of structures, particularly in summer homes and camps that are unoccupied in the winter. Active ingredients include black pepper oils, capsaicin, garlic oil, mustard oil, piperine, putrescent egg solids, and/or thymol. These are formulated as single ingredients or combinations of two or more ingredients.

Trapping

Live trapping can be used to remove one or a few squirrels from a building (Figures 12.6 D, E). Traps should be left open and unset for a few days and surrounded by attractive bait. Examples of baits include whole corn, sunflower seeds, peanuts, nutmeats, and rolled oats. Once the squirrels feed at the site, then set the trap for capture.

Handle trapped squirrels carefully. Always wear heavy gloves when moving the trap, as squirrels will readily bite you. Release captured squirrels at least 5 miles (8 km) away in a wooded area.

Where lethal control is permitted, rat snap traps can be used to kill squirrels in attics. The bait should be tied to the trigger and the trap secured with wire to a nearby wood rafter or beam. Check with local game conservation officers if you plan any kind of lethal control.

Snakes

Most snakes in the upper Midwest are nonpoisonous, harmless, and beneficial animals, but few people want them in their home.

IDENTIFICATION
Identifying the type of snake can be done through:

- www.HerpNet.net/Iowa-herpetology
- Or by printed material ("Iowa Reptiles and Amphibians," IAN 604, available through ISU Extension Distribution, 119 Printing and Publications Building, Ames, IA 50011 or by e-mail at pubdist@iastate.edu).

If snakes are a regular problem, the best solution is to eliminate hiding places. Clean up brush piles, woodpiles, rock piles, and other debris. Trim shrubbery away from foundations and cut tall grass.

Often, snake problems follow rodent populations. Eliminate the rodents and the snakes will move elsewhere seeking prey.

Snakes enter structures through broken block foundations, cracked mortar, damaged vents, or open crawlspace covers. These items should be repaired or closed.

Snake Management

Snake Removal

If a snake gets into a house or other building, it can be removed through several methods:

- Place damp burlap sacks on the floor and cover them with dry sacks. Check them every few hours to see if a snake has crawled underneath, seeking shelter. Lift the snake and bags with a shovel and take them outside to be released or killed.
- Use rat glue boards to capture all but the largest snakes. These boards should be tied down or attached to a plywood base. Place the glue boards along wall/floor junctions. Captured snakes can be killed or released from the glue by pouring vegetable oil over the snake's body.
- Place expanded trigger rat traps in pairs along wall/floor junctions. Make sure these are set in places out of reach of children and pets.

Repellent

A granular snake repellent can keep some species away from homes, camp sites, garages, and yards. The active ingredients are naphthalene and sulfur. The granules are applied in a narrow band around the area to be protected.

Skunks

IDENTIFICATION

- Adult body is 13 to 18 inches (33 to 46 cm) long. The tail is 7 to 10 inches (18 to 25 cm) long.
- Body weight varies from 2.5 to 14 pounds (1.2 to 6.3 kg).
- Fur color is black with a white triangle on the head and two white stripes down the back. The tail is bushy, black, and tipped with white.
- Legs are short with long claws on forelegs for digging.

There are two species of skunk: the common striped skunk (*Mephitis mephitis*) (Figure 12.7 A) and the endangered spotted skunk (*Spilogale putorius*) (Figure 12.7 B). These animals usually live in underground burrows, hollow logs, or rock piles. In certain situations, however, they may decide to live under houses, sheds, cabins, or outbuildings.

The main problem with skunks is their odor. They become pests when they change their dietary selections from rodents, insects, and wild fruit to garden crops, garbage, and lawn insects, and when they locate their habitat closer to humans. In some areas of the country, skunks also transmit rabies.

If a skunk sprays you or your pet, don't reach for the tomato juice, but gather baking soda, 3 percent hydrogen peroxide, and liquid dish detergent. In an open container, mix ¼ cup baking soda, a fresh 1 quart bottle of hydrogen peroxide, and 1 to 2 teaspoons of liquid dish detergent. This solution must be

used right away and cannot be stored. Thoroughly work the mixture into the fur/hair/skin, avoiding the eyes and mouth; leave on for 5 minutes. Rinse with fresh water and repeat.

Repellent

A repellent labeled for skunk control has the active ingredients capsaicin, black pepper oils, and piperine. Other products registered in some states include a smoke bomb (carbon, sulfur, and potassium nitrate) and the "Giant Destroyer" (carbon, sulfur, and sodium nitrate).

Raccoons

Raccoons (*Procyon lotor*)

IDENTIFICATION

- Adults are 30 to 38 inches (75 to 85 cm) long (nose to tip of tail).
- Adults weigh 15 to 40 pounds (7.5 to 20 kg).
- Mammal is medium-sized with stiff, long hair. Overall body color is gray, brown, or reddish black; mixture of light and dark fur colors help with camouflage; black fur around and below each eye forms a mask; ringed tail consists of yellowish white fur with black rings (Figure 12.7 C).

Raccoons are common throughout North America. Their natural habitat includes streams, lakes, and swamps, and they have adapted very well to suburban areas and city parks.

Raccoons den inside hollow trees or logs, rock crevices, deserted buildings, culverts, chimneys, attics, and crawlspaces (Figure 12.7 D). More than one den may be used.

Raccoons feed on animals and plants. In the spring and summer, these animals feed on crayfish, mussels, frogs, and fish. In the fall they switch to fruits, seeds, nuts, and grains. They will also eat mice, squirrels, birds, and garbage left by humans.

The raccoon can transmit rabies. This animal is the **definitive host** for a large intestinal roundworm, *Baylisacaris procyonis*, which has been documented in 68 to 82 percent of raccoons. This parasite can accidentally be picked up by pets and humans if they contact contaminated soil of raccoon latrines.

Repellent

As an example, repellents registered in Iowa have one of four active ingredient combinations:

- Garlic oil + capsaicin
- Meat meal + red pepper
- Capsaicin, black pepper oil, + piperine
- Camphor oil, cornmint oil, eucalyptus oil, + wintergreen oil

Figure 12.7. (A) Striped skunk pair; (B) Western spotted skunk; (C) Raccoon feeding in trash dumpster; (D) Raccoon in chimney; (E) Opossum; (F) Opossum in dog food storage container. Image credit: (A) Tom Friedel, Wikipedia Creative Commons; (B) Pearson Education, Inc.; (C) http://waterloo.batbirdanimalcontrol.com/; (D) Advantage Wildlife Removal, www.sitesbyrobb.com; (E) Cody Pope, Wikipedia Creative Commons; (F) http://metallicpea.wordpress.com

Opossum

Opossums (*Didelphus virgiana*)

IDENTIFICATION

- Adult body is 13 to 37 inches (35 to 94 cm) long and the tail is 8.5 to 19 inches (22 to 47 cm) long.
- Adult males weigh 1.7 to 14 pounds (0.8 to 6.4 kg) and females weigh 11 ounces to 8.2 pounds (0.3 to 3.7 kg), about the size of a domestic cat.
- Fur color is grayish brown with a white face. Eyes, paws, and hairless ears are black. The nose is long, flat, and pink. Its naked tail is capable of grasping branches or other objects (Figure 12.7 E).
- Animal is solitary.

Opossums prefer to live near wooded areas with access to a stream or swamp. They den in the burrows of other large animals, in tree cavities, brush piles, and under sheds and buildings. Occasionally, they move into attics and garages.

These animals are omnivores, eating insects, carrion, fruits, grains, garbage, and pet food. As a pest, the main complaint with opossums is their habit of getting into garbage, bird feeders, and pet food left outside (Figure 12.7 F).

There are no chemicals registered to repel opossums.

Management of Skunks, Raccoons, Opossums

Sanitation

Community involvement in keeping good sanitation levels in a neighborhood is the best preventive measure for skunks, raccoons, and opossums. Examples of good sanitation practices include:

- Using garbage containers with tight fitting or latched lids;
- Securing cans so they cannot be tipped over;
- Picking up remaining pet food;
- Picking up and discarding fallen fruits on a regular schedule;
- Trimming back tree branches that overhang buildings;
- Eliminating long-standing brush piles; and
- Removing old, hollow trees and logs on the property.

Exclusion

These animals can be prevented from entering buildings by several methods, depending on where they are living:

- Repair breaks in foundations with appropriate materials.
- Screen crawlspace vents with hardware cloth.
- Seal attic openings (Figure 12.8 A).

- Cap chimneys with a wire cage or other animal-proof cover (Figure 12.8 B).
- Seal all openings but one, if an animal appears to be living under a building; sprinkle talc powder at the last opening; examine area after dark; and if animal has left, close opening.
- Install electric fence around garden areas, if needed. A two-wire fence with one wire 6 inches off the ground and the second 12 inches high will discourage hungry animals (Figure 12.8 C).

When excluding animals in spring or early summer, be aware that young also may be present. To prevent odors from dead animals, be sure that all animals have been removed before sealing the building.

Live Trapping

The best way to remove animals from structures is to trap them (Figure 12.8 D). Some guidelines include:

- Handle trapped animals with extreme care; always wear heavy gloves and a heavy jacket/coat.
- Release a trapped animal far away (10 miles; 16 km) from human dwellings or nearby buildings. Check with state wildlife officers for the best possible release sites.
- Set traps as close to the den as possible or as close to the areas being damaged, such as at corners of gardens, breaks in stone walls, or along obvious animal trails.
- Set multiple traps in a number of different locations.
- Check traps at least each morning, or, if possible, twice a day. Release any nontarget animals trapped.
- Kill a trapped animal, if necessary, by completely submersing the trap in water.

For trapping skunks, it is very important to modify the site to prevent being sprayed. Cover all but the trap entrance with burlap sacks or canvas before placing the trap. Commercially available skunk traps are available. When a skunk is trapped, approach the trap slowly and transport it gently. To live release the skunk, stand at least 20 feet (6 m) away and release the trap with string or fishing line.

The best baits for each animal are as follows:

- Skunk – chicken parts and entrails, fresh fish, cat food, sardines, eggs
- Raccoon – chicken parts and entrails, corn, fresh fish, sardines
- Opossum – apple slices, chicken parts and entrails, fresh fish, sardines

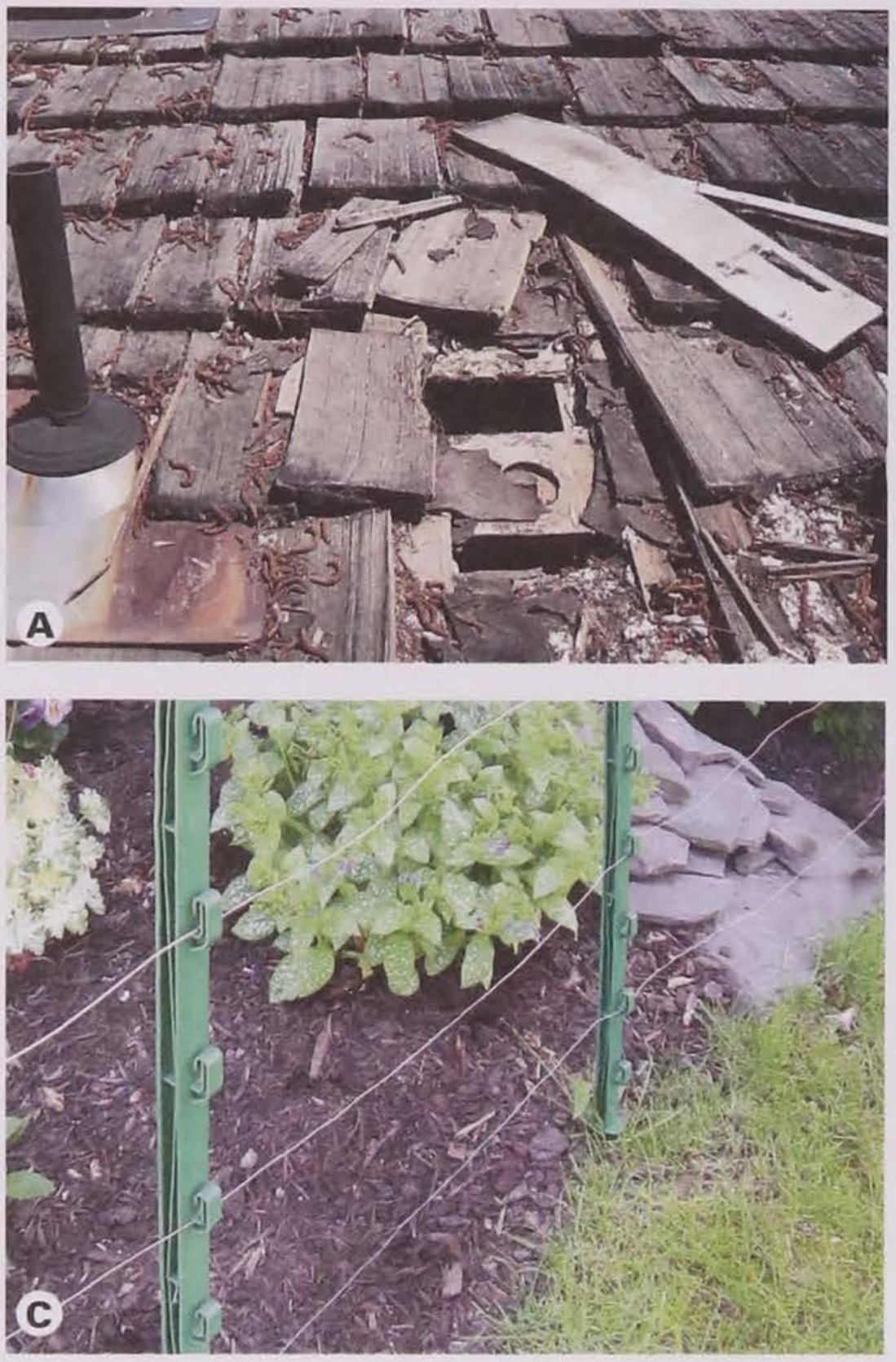


Figure 12.8. (A) Raccoon entry hole to attic; (B) Installing chimney caps; (C) Electric fencing; (D) Trapped striped skunk. Image credit: (A) www.critter-company.com; (B and D) www.vamoosevarmint.com/; (C) http://multivu.prnewswire.com

Glossary

Abdomen. The hindmost part of an insect's body, which contains the digestive and reproductive organs. **1**

Action threshold. The pest level at which some type of pest management action should be taken. **1**

Active ingredient. The primary chemical(s) making up a pesticide that is biologically active. **3**

Adult. Fully grown, sexually mature insect. **3**

Alternate host. A species of host that is immediately available and different than the principal host on which an ectoparasite can survive. **8**

Antenna (pl. antennae). The pair of jointed appendages on the head of an insect. antennae are used to sense the environment. **3**

Anticoagulant. Any substance that prevents the clotting of blood. **11**

Avicide. A pesticide used to repel or kill birds. **12**

Bait. A food or other substance used to attract a pest to a pesticide or a trap. The active ingredients are mixed with food and the pest is killed when the bait is consumed. **1**

Bait translocation. The movement of a pesticide bait from the area of application to another area by a pest organism. **11**

Ballooning. The mechanical kiting used by some arthropods (e.g., caterpillars, mites, spiders) to disperse through the air from one location to another. **10**

Barrier treatment. Application of a band of insecticides on the lower portion of a building, around the building perimeter and/or near doorways or window. **1**

Budding. The breakaway of a group of ants from a parental/main colony to form a new colony. this process can be a natural phenomenon based on colony dynamics or it can be initiated in response to a residual insecticide treatment. **4**

Cache. A hiding place used for storing provisions (e.g., food, nesting materials) by rodents. **11**

Canine detection. Use of specially trained dogs to locate various substances or organisms. in this manual, it refers to using dogs to find bed bugs. **8**

Caste. A group of colony members that specialize on particular tasks for prolonged periods of time. specialized individuals within the social organization of certain insects. **3**

Cephalothorax. The anterior body region of certain arthropods (e.g., spiders) consisting of a fused head and thorax. **10**

Commensal. Animals that have adapted to the human environment (its structures, food storage, and waste) as a source of food, water, and shelter. **11**

Complete metamorphosis. Insect development that involves four stages (egg, larva, pupa, and adult). each stage differs in appearance and often in habitat and food requirements. **1**

Conducive conditions. Those situations in a structure that promote favorable pest development, including entry points, ways of moving within a structure, sanitation levels, and available water, food, and shelter. **3**

Contact insecticide. An insecticide that kills when it touches or is touched by a pest; it need not be ingested to be toxic. **2**

Crack and crevice. Application of small amounts of insecticides into cracks and crevices in which insects hide or through which they may enter a building. **1**

Crawlspace. A low or narrow space that allows access to utility services. this can be an area between two floors of a building or below the lowest floor of residential buildings, in lieu of a basement. **4**

Definitive host. An organism that supports the adult or sexually reproductive form of a parasite. **12**

Delusional infestation. The conviction, against all medical evidence, that insects or other organisms are crawling on, biting, or burrowing into the skin. Also called illusory parasitosis or Ekbom's syndrome. **8**

Echolocation. The location of objects by reflected sound used by some animals, including bats and rodents. **11**

Ectoparasite. A parasite that feeds on another organism from the outside. examples are fleas, lice, and bed bugs. **8**

FIFRA. Acronym for the federal insecticide, fungicide and rodenticide act. **inside front cover**

Food-handling establishment. An area or place other than private residence in which food is held, processed, prepared, and/or served. **1**

Gaster. The rounded part of the abdomen posterior to the node-like segment of ants. **4**

Gradual metamorphosis. Insect development that involves three stages (egg, nymph, and adult). nymphs and adults look similar and have similar habitat and food requirements. **1**

Gregarious. Animals that tend to form a group with others of the same species without forming distinct colonies. **3**

Guard hair. A long, coarse hair forming an animal's outer fur, rising above the under fur. **11**

Harborage. A place providing shelter or refuge for a pest organism. **1**

Hierarchy. A series of ordered groupings within a group of animals. **11**

Hypostome. An appendage on the oral opening of some insects and arachnids. **8**

IGR. Acronym for insect growth regulator **1**

Incidental host. A vertebrate animal or human infected with a disease-causing agent that is not essential to the development and transmission of the disease; also called a dead-end host. **8**

Insect growth regulator. A type of pesticide that controls insects by disrupting normal growth and development, rather than by toxic action. **1**

Integrated pest management. An ecological approach to pest management in which all available, necessary techniques are consolidated into a unified program so that pest populations can be managed in such a manner that economic damage is avoided and adverse side effects are minimized. **1**

IPM. Acronym for integrated pest management. **1**

Larva (pl. larvae). An immature stage of an insect that undergoes complete metamorphosis. a larva is an active, feeding stage of the insect. the larval stage follows the egg stage and precedes the pupal stage. **1**

Loafing site. A place where a pigeon rests between daytime activities. **12**

Kinesthetic sense. Any of the physical processes by which environmental stimuli are received and processed by the brain, giving the animal an awareness of its position, location, and/or movement. **11**

Maggot. A soft-bodied legless larva of a fly, which feeds on decaying plant matter or animal flesh. **1**

Metamorphosis. The change in body form during the life cycle of an organism. **1**

Microbial fermentation. The breaking down of a substance by the action of microorganisms. **5**

Mode of action. A description of how a pesticide exerts a toxic effect on a target pest and what specific system(s) are affected in the pest organism. **1**

Monitoring. Planned, regular inspection of a crop, ornamental planting, landscape, or structure for the purpose of detecting pests, pest damage, or conditions conducive to pests or pest damage. **1**

Nit. The egg, spent egg case, or young form of a louse, especially that of a head louse. usually found attached to the hair shaft. **8**

Nymph. The developmental stage of an insect with gradual metamorphosis between the egg and adult stages. nymphs appear as miniature adults. **1**

Omnivore. An animal that eats a variety of food of both plant and animal origin. **11**

Ootheca (pl. oothecae). The egg case of a cockroach. **3**

Paraffinized. Incorporation of paraffin/wax in the formulation of a rodenticide to improve shelf-life, safety, and weather resistance. **11**

Pediculosis. An infestation of lice. **8**

Petiole. The narrow stalk or stem by which the abdomen is attached to the thorax in ants. **4**

PMP. Acronym for pest management professional. **1**

Preadult. The stage in a flea life cycle between the pupa and the emerged adult. the insect remains in this stage for a prolonged period (up to 12 months) until conditions are appropriate for feeding. **11**

Pronotum. The first segment of the thorax of an insect. **3**

Pupa (pl. pupae). An intermediate "resting" stage of an insect that undergoes complete metamorphosis between the larval and adult stages. pupae do not feed and are usually not mobile. **1**

Residual insecticide. An insecticide that continues to be effective for an extended period of time after application. **1**

Runway. A path over which rodents regularly run to access food, water, or shelter in their territory. **11**

Satellite colony. Colonies formed outside the main, reproductive colony by carpenter ants, which contain large numbers of foraging workers but lack a queen or developing young. **4**

Scutum. The hard shield on the back of a tick, which expands over the entire back of males but only ⅓ of the back of females. **8**

Secondary hazard. The potential life-threatening results nontarget predatory or scavenger organisms, resulting in exposure to, or consumption of, prey tissue containing a chemical in its original or altered form. **11**

Secondary pest. A pest that becomes a larger problem when conditions favor its development or when its competition is eliminated in some manner. **9**

Sex pheromone. Specific chemicals produced by female insect to attract males for mating. **6**

Shelf life. The amount of time that a product can be stored and remain effective for pest management activities. **1**

Space treatment. Application of a fine, aerosol mist of insecticide into any sized, open area with the intent of providing a rapid knockdown and death of the pest organism, with little or no residual effects. **1**

Spot treatment. Application of a pesticide to a small, distinct area. **1**

Synergist (verb: synergized). Any admixture to a substance that increases the effectiveness of one or more of its properties. **9**

Swarm. A large number of winged insects (e.g., ants, bees, termites). **4**

Thigmotactic response. The motion or orientation of an organism in response to touch stimuli. **3**

Thorax. The region of the insect body bearing the legs and wings. **1**

Threshold. A point at which pest populations or environmental conditions indicate that pest control must be taken without risk of significant damage. **1**

Trail pheromone. Chemicals secreted by an animal for the purpose of impacting the behavior of another like animal receiving it. Usually lead other members of a species to a food source. **4**

Trophallaxis. The transfer of food or fluids among members of an insect community through mouth-to-mouth or anus-to-mouth feeding. Highly developed in ants, bees, wasps, and termites. **4**

Vertebrate. An animal with a spinal column protected by a series of bones (vertebrae) and a skull that protects the brain. **11**

Void treatment. Application of an insecticide into an empty space (e.g., wall, ceiling, behind a kick plate, table leg, or in any other void that constitutes a prime pest harborage site. **1**

Vibrissa (pl. vibrissae). Specialized hairs in certain animals used for tactile sensation. Usually found around on the head near the mouth and nose. **11**

APPENDIX A

Understanding Pest Management Concepts

In addition to careful reading of the information in this manual and addressing each learning objective, the following items will help you best understand the pest management concepts for general and structural pests. Think about these things while re-reading the manual. These concepts can also be used in company meetings for training purposes.

1. Differentiate between the immature stages of insects undergoing gradual versus complete metamorphosis.

2. Formulate how you would inspect a structure for the presence of:
   A. Cockroaches
   B. Ants
   C. Stored product pests
   D. Bed bugs
   E. Commensal rodents

3. Evaluate the effectiveness of non-chemical control tools for:
   A. Cockroaches
   B. Ants
   C. Nuisance flies
   D. Stored product pests
   E. Accidental invaders
   F. Blood-feeding pests
   G. Stinging pests
   H. Spiders
   I. Rodents
   J. Other vertebrate pests

4. Describe how water accumulation near a foundation affects pest levels.

5. Rank the top five voids used as a harborage by rodents.

6. State what would constitute an environmental hazard when using a pesticide in/near a structure.

7. Design a monitoring program for common pests in a commercial kitchen (40 feet x 130 feet).

8. List the household and structural pests that have shown pesticide resistance.

9. Explain how product avoidance affects pest management for:
   A. Cockroaches
   B. Rodents

10. Describe how human habits and construction practices assist the movement/distribution of common pests.

11. List the general and structural pests that are not affected by seasonal changes.

12. List the potential problems associated with applying an insecticide inside a structure.

13. Name the ways a pesticide application can move off-target inside and outside a structure.

14. Identify the sensitive sites on a property:
   A. Residential
   B. Commercial
   C. Health care facility
   D. Food preparation facility

15. Describe how mulch, long grass, shrubbery, and trees can affect a pesticide application and pest management.

16. Design a pest management program for pests of: food pantries; fabric; paper goods

17. Design a pest management program for accidental invaders in a given structure.

18. Outline a management program for stinging pests near a structure.

19. Outline a rodent management program, including sanitation, exclusion, trapping, and rodenticides.

20. Design an integrated management program for birds in/on a structure.

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Cover Images

Black rat
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Farm2.static.flickr

Oriental cockroach
Dimocritus
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Pavement ant
April Nobile
Antweb.org

Larder beetle
Joseph Berger
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Common starlings
Mike Watson
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House
Catherine Goodner
http://thestaginglifestyle.com

Calliphoridae fly
Morten Pedersen
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Bald faced hornet
Allcountypestcontrol.com

Ground beetle
Secundus
Odd-draw.blogspot.com

Rice weevil
Olaf Leillinger
Wikipedia

Eastern gray squirrel
Sage Ross
Wikipedia

Bed bug
killbedbugs.com/blog

Emergency Telephone Numbers

Regional Poison Center.....**1 (800) 222-1222**
For pesticide emergencies, state poison centers provide service that is free of charge to the public and is available 24 hours a day, seven days a week

Environmental Emergency Response
For pesticide spill emergencies
Iowa – Iowa Department of Natural Resources.....**(515) 281-8694**

Chemtrec Emergency Hotline.....**1 (800) 424-9300**

National Pesticide Information Center.....**1 (800) 858-PEST(7378)**
Call the NPIC network toll-free
Hours: 9:30 a.m. to 5:30 p.m., Monday through Friday (CST)

U.S. Environmental Protection Agency (EPA).....**(913) 281-0991**
All major pesticide spills must by law be reported immediately to the U.S. Environmental Protection Agency, Region VII Office, 11201 Renner Boulevard, Lenexa, KS 66219. The following information should be reported:

1. Name, address, and telephone number of the person reporting
2. Exact location of spill
3. Name of company involved and location. Specific pesticide spilled
4. Estimated quantity of pesticide spilled
5. Source of spill
6. Cause of spill
7. Name of body of water involved, or nearest body of water to the spill area
8. Action taken for containment and clean-up

Iowa Department of Agriculture and Land Stewardship Pesticide Bureau
Pesticide General Information.....**(515) 281-8591**
Licensing and Certification.....**(515) 281-5601**