GENERAL PEST CONTROL

CATEGORY 10A

A Study Guide for Commercial Applicators
General Pest Control
A Guide for Commercial Applicators
Category 10a

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INTRODUCTION

How to Use This Manual
This manual contains the information needed to become a licensed commercial applicator in Category 10a, General Pest Control. This manual is intended for use with the 10a Color Supplement. However, this manual would also be useful to anyone who is interested in learning about structural pest and his or her control.

General Pest Control covers the management and control of pests in homes, food processing facilities, businesses, office buildings, hospitals, health care facilities, storage areas, industrial plants, schools and other structures. It discusses control and management of insects, other arthropods, and vertebrate pests that become problems inside buildings. The chapters contain basic scientific information as well as guidelines for practical solutions to pest control problems. This manual is divided into four sections:

Section 1 – General Information and Principals of Pest Management – covers general pest management and control including legalities, equipment use, and basic methods of pest control.

Section 2 – Structure-Infesting Pests – covers insects that commonly live inside buildings.

Section 3 – Occasional Invading Pests – covers insects that invade buildings from outside habitats.

Section 4 – Mice, Rats, and Voles – covers vertebrate animals such as mice, rats and voles that can become pests of structures.

The Category 10a licensing exam will be based on information found in this manual and the supplemental manual. Each chapter begins with a set of learning objectives that will help you focus. As you prepare for the exam, read each chapter. The exam questions are taken from the entire manual. We would like to wish you good luck on your studying and on your exam.
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SECTION 1

GENERAL INFORMATION AND PRINCIPALS OF PEST MANAGEMENT

The information contained in this section will explain some of The Ohio Department of Agriculture’s laws that govern the pesticide applicator. There is also information that tells you about testing, licensing, and recertification. Basic pest biology is in this section as well. This section has a lot of basic applicator information needed to perform pesticide application correctly and safely.
LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Know the Federal Laws regulating pesticides
- Know the State Laws regulating pesticides
- Know what the role is for an applicator working in the Pest Management industry
- Learn about record-keeping and what the applicator should know
- Protection of the environment
- Use, handling, and storage of pesticides
- Understand the meaning of a pesticide-use category definition
- Why we have an EPA approved State Plan
- The applicator’s responsibilities
- Know what a category definition is
- Learn about exams, what is required, how to check results, etc.
- Understand the recertification process, what it is, and how it works
- Know what it means to be a licensed commercial applicator

FEDERAL LAWS

The federal laws include the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), Occupational Safety and Health Act (OSHA) and Endangered Species Act (ESA).

FIFRA — This is the basic federal law, administered by the US Environmental Protection Agency (USEPA) that regulates pesticides — their use, handling, storage, transportation, sale, disposal, etc.

The Ohio Department of Agriculture (ODA) has a cooperative agreement with the USEPA to enforce some parts of FIFRA. Selling or using a pesticide before registration, is a violation of the Law.

Pesticides are either “general-use” or “restricted-use”. Anyone can buy and use general-use pesticides. You can buy or use restricted-use pesticides with an active license and specific category only.
FIFRA also stipulates that people who use pesticides “inconsistent with the pesticide label” are subject to penalties.

**OSHA** — OSHA is administered by the US Department of Labor (DOL). OSHA governs the recordkeeping and reporting requirement of all work-related deaths, injuries, and illnesses within businesses of 10 or more workers. Businesses with 10 or more workers will be subject to periodic inspections.

**Endangered Species Act** — This act requires the USEPA to make sure that endangered or threatened plant and animal species are protected from pesticides. Requires each pesticide label to limit its use in areas where it is harmful to these species. The Ohio Department of Natural Resources (ODNR) Division of Wildlife maintains the federal and state endangered threatened species lists. Ohio applicators need to be sure that they are complying with the law. They must take the initiative to consult with the ODNR or check the lists to be sure that there are no endangered or threatened species in their application area.

**STATE LAWS**
The Ohio Revised Code (ORC) and Ohio Administrative Codes (OAC) are the law and regulations that allow ODA to control who uses pesticides, how pesticides are mixed, loaded, applied, and the disposal process.

**The Ohio Pesticide Law** — This legislation gives the director of ODA authority to license private and commercial applicators. The Director also prescribes standards for licensing. Category 10a applicators are commercial applicators or Trained Servicepersons.

- **Commercial Applicators** — Any licensed person who applies, uses or supervises the use of general-use or restricted-use pesticides (RUPs) for their employer or for hire.

- **Trained Serviceperson** — Any person who (1) applies pesticides in the course of their employment, or (2) applies a pesticide for hire.

**The State Plan for Ohio** — The State Plan for Ohio is the document that designates the Ohio Department of Agriculture as the State Lead Agency by a letter from the Governor dated March 12, 1973. The plan also designates that The Ohio State University is the Land Grant University.

The State Plan is a requirement of the USEPA to regulate general-use and restricted-use applications and applicators. The ODA regulates pesticides by investigating complaints from the public. ODA also does required federal and state inspections of application businesses, pesticide dealers and pesticide applicators for compliance.

**Ohio Department of Agriculture Personnel engaged in the implementation:**

1. The Director of Agriculture
2. The Chief of the Division of Plant Industry
3. Deputy Chief of Plant Industry and of Pesticide Regulation Section
4. Full Time Field Inspectors
5. Field Inspector Supervisors
6. Certification and Training Manager

The Ohio State University (OSU) and the ODA have a Memorandum of Understanding (MOU) stating that the University will be the training entity.

OSU and Industry conducts numerous trainings throughout the year. The trainings target commercial applicators. At the county level, OSU educators hold a number of private and commercial programs, mainly in the agriculture, greenhouse, and ornamental categories.

**Implementation personnel:**

1. OSU Vice President and Dean of the College of Food, Agriculture and Environmental Sciences
2. Associate Director, OSUE
3. Assistant Director, Agriculture and Natural Resources Pesticide Applicator Training Coordinator

- Entomologists
- Agronomist
- Wildlife Specialists
- Horticulturalists
- Plant pathologists
THE ROLE OF A PESTICIDE APPLICATOR

Pest Management (PM) can be complex. It is a matter of using the right tools. This requires special equipment and safety measures. To do well in PM it must be effective. It should not have a negative affect on people or the environment. What is the environment you might ask? Environment is the air. It is the water. It is the soil. It can be inside or outside structures. Simply, it is everything around us.

The number and variety of pesticides have increased. Pesticide applicators need to know more about safety and proper use more than ever before. For these reasons, many state, federal laws and regulations help protect the public. They also protect the environment, pesticide applicators, and handlers from the possible bad effects caused by pesticide use.

Applicators certified in Category 10a are responsible for pest management in and around all structures including homes, schools, hospitals, businesses, warehouses, etc. It is important that Category 10a applicators understand and keep up to date with the laws that regulate pesticide applications inside or around buildings. Ignorance of the law is never an accepted excuse for a violation.

Protection: The applicator’s responsibility —

Responsibility for protecting the environment from the possible bad effects of pesticide use rests on the applicator. Preserving the natural variety of our planet by protecting the environment contributes to the quality of life. Each plant and animal is part of a complex food chain. If you break one of the links then others are badly affected. One vanishing plant can affect up to 30 other species that depend on it. This includes insects, higher animals and even other plants. Applicators may see their normal work as unlikely to affect the environment, but spills and leaks while mixing, loading, and transporting, or incorrect disposal can lead to pesticides in ground or surface water or in the home of non-target organisms. Applicators often service parks, schools and other sensitive areas. Category 10a applicators have an even greater responsibility toward the public because of the indoor use of pesticides. There is a greater risk of exposing people to pesticides in these enclosed spaces. Minimal use of pesticides is the goal in these areas. You need to apply pesticides in a manner that will prevent contact with humans and other non-target sites.

Use, Handling, and Storage: The applicator’s responsibility —

It is the applicator’s job when applying or handling pesticides to follow all label instructions and requirements. The applicator must apply without causing harm to the environment, human life, non-target animal life or plant life.

The applicator should READ THE LABEL. They must understand what personal protective equipment (PPE) is, how and why it is used in order to perform a safe application. Remember THE LABEL IS THE LAW! An example of PPE would be long pants. Long pants protect the legs of an applicator from dermal (skin) exposure.

Storage requirements for pesticides are on the label as well as additional requirements by the USEPA and OAC 901:5-11-11. See the laws and regulation in the Core Material.

What does this mean to you?

You may or may not do the handling, loading, or storage of pesticides for your applications. This does not exempt you from knowing the requirements. You must know how to deal with them in case you might handle, mix, load, or store pesticides in the future. It is your responsibility to keep informed about the laws and regulations of pesticides.

Record keeping: The applicator’s responsibility —

The ORC and OAC establishes the types of licenses for applicators and record-keeping requirements. All commercial applicators shall maintain records of their pesticide use for a time not less than the following:

General-Use Pesticides: Three years following the application.
Restricted-Use Pesticides: Three years following the application.

All pesticide application records according to 901:5-11-10 of the OAC shall include the following information:

Applying pesticides to structures and their contents

- Name and business address of responsible commercial applicator and names of the trained servicepersons applying pesticides under the commercial applicator’s direct supervision;
- Date of application
- Principle pests to be controlled
- Locations and methods of treatment for each pesticide used
- Trade name (brand name) and EPA registration number of pesticides used
- Total amount of each pesticide product used
- Application rate for each pesticide used
- If diluted, total volume of use dilution applied
- Time of day of application, including the time of starting and the actual application and the time of completion of application or, if uncompleted, the time when operation ceased for the day

The applicator shall submit an application record, within ten days following the date of completion, to the registered pesticide business location from which the application was conducted or the commercial applicator’s employer if the employer is not a pesticide business.

**What does this mean to you?**
The applicant who actually applies the pesticide is the responsible party. The records must have all the information required by the Law. An ODA inspector will call on you periodically to check records. If your recordkeeping documents are incomplete, you have violated ODA law. You will be subject to a range of actions from a letter of warning to license revocation.

**PESTICIDE-USE CATEGORY DEFINITION**
The pesticide-use categories are found in the Ohio Administrative Code Section 901:5-11-01.

The pesticide-use category definition for Category 10 is “Domestic, institutional, structural, and health-related pest control” which means the indoor or outdoor applications of pesticides to control pests of humans, their dwellings, work spaces, and other structures used or occupied by humans, and the clothing, furnishings, and stored, processed, or manufactured food products contained therein.

There are four sub-categories for 10. This study guide relates to sub-category a that is “General pest control”. General pest control means the application of pesticides in or around human dwellings, industrial plants, and business offices, food handling establishments, schools, hospitals, or other institutions warehouses, grain elevators, or similar buildings to control pests, including rodents of such structures or of the occupants, furnishings, or provisions of those structures, except for the control of pest birds, termites, and fungi. If this is not the category (10a) that you need or want, please contact the Ohio Department of Agriculture – Pesticide and Fertilizer Regulation Section to get the category you need. Pesticide and Fertilizer Regulation Section information is as follows, phone numbers are (614) 728-6987 or (800) 282-1955 or contact us by email pesticides@agri.ohio.gov.

**REQUIREMENTS OF COMPETENCY**
ODA receives the Requirements of Competency from the State Plan for Ohio mentioned earlier in this chapter. The standards of competency for Category 10a are as follows:

(10a) General Pest - Commercial applicators shall demonstrate a practical knowledge of:

- common pests of stored products, food establishments, living quarters, etc., their habits, breeding sites, life cycles and stages for optimum control
- pesticide formulations for controlling these pests
- methods of application to avoid food and feed contamination or undue human or domestic animal exposure
- safety and application equipment used in these applications
- calculating rates and amounts of pesticides to be used in these applications per label instructions
- modes of action of pesticides being used
- re-entry intervals to minimize exposure to pesticides or residues
- information necessary for safe and adequate application of pesticides
- proper interpretation of label instructions

**What does this mean to me?**
These standards used in development of the study guides and competency exams are for people who want to become licensed applicators.

Competency exams have questions about subjects such as common pests, exposures, etc. You should learn all you can from the guides. You could come across a particular insect, disease or vertebrate pest in the future.

Knowledge will help you pass your exams and be a competent applicator. The more knowledge of a topic, the better equipped you are to pass your exams.

**DEMONSTRATION OF COMPETENCE and PESTICIDE EXAM REQUIREMENTS**
OAC 901:5-11-08
(A) Each applicant for a pesticide applicator license shall show, by passing a general Core examination and an examination for each applicable pesticide-use category, that the applicant possesses adequate knowledge of general pesticide application principles and competence to apply pesticides and, in the case of commercial applicants, adequate knowledge and competence to conduct diagnostic inspections within the pesticide-use categories for which the applicant seeks licensure.
(1) Opportunity to take examinations will be provided at such times and places as determined by the director in consideration of the number and location of requests.
(2) Pesticide applicators may apply to broaden their license to include a new pesticide-use category at any time.

(3) In establishing the standards for training and examination of pesticide applicators, the director will be guided by the standards set forth in the “State Plan for Certification of Applicators” as approved by the administrator of the United States Environmental Protection Agency.

(4) Each applicant for licensure as a commercial applicator in the category of wood-destroying insect diagnostic inspection shall submit a valid certificate verifying that they have completed the Ohio wood-destroying insect inspection program.

(5) Applicants who fail to pass an examination may apply to be re-tested at a pre-arranged time and location, but no earlier than five business days after a previous examination except by special permission of the director.

(6) Applicants must pass a core examination and a pesticide-use category examination to be issued a license. If an applicant fails either the core or all pesticide-use category examinations they have taken, the applicant shall not receive a license until both the core and at least one pesticide-use category examination have received a passing score. The applicant has one year from the date of the first examination for which the applicant has obtained a passing score to obtain licensure. If the applicant is unable to obtain licensure within that year, the applicant must pass anew both a core examination and a pesticide-use category examination, even if the applicant had previously received a passing score on either the core or a pesticide-use category examination.

(B) Re-examination shall be required at three-year intervals, except that a pesticide applicator may be exempted from re-examination if they have participated in the minimum amount of approved training during the three years prior to the date of their scheduled re-examination. Notwithstanding the minimum number of hours set forth below, a licensee shall participate in at least one-half hour of training for each pesticide-use category in which they are licensed in order to avoid re-examination in that particular category.

(1) For commercial applicators, the minimum amount of approved training required shall be five hours. Of the five hours, at least one hour shall consist of core training material and at least one-half hour shall consist of training material specific to the pesticide-use category in which the commercial applicator is licensed.

(2) For private applicators, the minimum amount of approved training required shall be three hours. Of the three hours, at least one hour shall consist of core training material and at least one-half hour shall consist of training material specific to each pesticide-use category in which the private applicator is licensed.

(C) In no case shall an applicant be permitted to take an examination or a re-examination unless the applicant has presented at the time of the examination or re-examination current government-issued photographic identification to the ODA representative administering the examination or re-examination. This paragraph shall not apply to an applicant whose religion does not permit the applicant to be photographed.

Requirements to become a licensed pesticide applicator are 1) pass a core exam, 2) pass at least one category exam and 3) submit an application and fee. Once these requirements are met a license will be issued to you.

A very important note: passed exams are only valid for one year from the date you passed the exam(s) unless you are issued a license at that time. If you do not meet the requirements within that year of the valid exam, the exam will become void and you will have to retest. Exams for licensed pesticide applicators are valid as long as the license is valid.

You can review your exam status on ODA’s web site www.Ohioagriculture.gov. Then choose Online Services, look for Plant Industry, then Pesticides, then exam results search.

RECERTIFICATION REQUIREMENTS OAC 901:5-11-08

The requirements of the law are: (B) Re-examination shall be required at three-year intervals, except that a pesticide applicator may be exempted from re-examination if they have participated in the minimum amount of approved training during the three years prior to the date of their scheduled re-examination. Notwithstanding the minimum number of hours set forth below, a licensee shall participate in at least one-half hour of training for each pesticide-use category in which they are licensed in order to avoid re-examination in that particular category.

(1) For commercial applicators, the minimum amount of approved training required shall be five hours. Of the five hours, at least one hour shall consist of core training material and at least one-half hour shall consist of training material specific to the pesticide-use category in which the commercial applicator is licensed.

What does this mean to me? This means that you are responsible to either retest or get recertification (continuing education) credits to keep your license active. You should know what credits you need, how many credits you need and by what date you need the credits.

As the Pesticide Law states, a recertification period is for three years from the date that you first receive a license and become a licensed applicator. Recertification cycles after that are at three-year intervals as long as you have an active license. You can only earn credits for the current recertification period. Credits earned over the minimum requirements DO NOT carry over to the next cycle.

You can look-up your recertification status on ODA’s web site www.Ohioagriculture.gov. Select Online Services, Plant Industry, Pesticides, then recertification information.
LICENSING REQUIREMENTS ORC 921.06
(A)(1) No individual shall do any of the following without having a commercial applicator license issued by the director of agriculture:
(a) Apply pesticides for a pesticide business without direct supervision;
(b) Apply pesticides as part of the individual’s duties while acting as an employee of the United States government, a state, county, township, or municipal corporation, or a park district, port authority, or sanitary district created under Chapter 1545., 4582., or 6115. of the Revised Code, respectively;
(c) Apply restricted use pesticides. Division (A)(1)(c) of this section does not apply to a private applicator or an immediate family member or a subordinate employee of a private applicator who is acting under the direct supervision of that private applicator.
(d) If the individual is the owner of a business other than a pesticide business or an employee of such an owner, apply pesticides at any of the following publicly accessible sites that are located on the property:
   (i) Food service operations that are licensed under Chapter 3717. of the Revised Code;
   (ii) Retail food establishments that are licensed under Chapter 3717. of the Revised Code;
   (iii) Golf courses;
   (iv) Rental properties of more than four apartment units at one location;
   (v) Hospitals or medical facilities as defined in section 3701.01 of the Revised Code;
   (vi) Child day-care centers or school child day-care centers as defined in section 5104.01 of the Revised Code;
   (vii) Facilities owned or operated by a school district established under Chapter 3311. of the Revised Code, including an education service center, a community school established under Chapter 3314. of the Revised Code, or a chartered or nonchartered nonpublic school that meets minimum standards established by the state board of education;
   (viii) Colleges as defined in section 3365.01 of the Revised Code;
   (ix) Food processing establishments as defined in section 3715.021 of the Revised Code;
   (x) Any other site designated by rule.
(e) Conduct authorized diagnostic inspections.
(2) Divisions (A)(1)(a) to (d) of this section do not apply to an individual who is acting as a trained serviceperson under the direct supervision of a commercial applicator.
(3) Licenses shall be issued for a period of time established by rule and shall be renewed in accordance with deadlines established by rule. The fee for each such license shall be established by rule. If a license is not issued or renewed, the application fee shall be retained by the state as payment for the reasonable expense of processing the application. The director shall by rule classify by pesticide-use category licenses to be issued under this section. A single license may include more than one pesticide-use category. No individual shall be required to pay an additional license fee if the individual is licensed for more than one category.
The fee for each license or renewal does not apply to an applicant who is an employee of the department of agriculture whose job duties require licensure as a commercial applicator as a condition of employment.
(B) Application for a commercial applicator license shall be made on a form prescribed by the director. Each application for a license shall state the pesticide-use category or categories of license for which the applicant is applying and other information that the director determines essential to the administration of this chapter.
(C) If the director finds that the applicant is competent to apply pesticides and conduct diagnostic inspections and that the applicant has passed both the general examination and each applicable pesticide-use category examination as required under division (A) of section 921.12 of the Revised Code, the director shall issue a commercial applicator license limited to the pesticide-use category or categories for which the applicant is found to be competent. If the director rejects an application, the director may explain why the application was rejected, describe the additional requirements necessary for the applicant to obtain a license, and return the application. The applicant may resubmit the application without payment of any additional fee.
(D)(1) A person who is a commercial applicator shall be deemed to hold a private applicator’s license for purposes of applying pesticides on agricultural commodities that are produced by the commercial applicator.
(2) A commercial applicator shall apply pesticides only in the pesticide-use category or categories in which the applicant is licensed under this chapter.

What does this mean to me? Once you have submitted your application, fee, and passed your exams, your license is issued. This will allow you to perform applications.

A commercial applicator applies pesticides for hire. They apply for a pesticide business without direct supervision. They perform diagnostic inspections. They apply for their employer a governmental or state agency. They apply on the property of their employer on any of the following publicly accessible sites:
- food service operations
- retail food establishments
- golf courses
- rental properties of more than 4 apartment units at one location
- hospitals or medical facilities
- child day-care centers, or school day-care centers
- facilities owned or operated by school districts, or education service centers
- community school
- chartered or non-chartered non-public school.
The licensing fee of $35.00 is good for all categories. There is no charge for adding additional categories to your license. Contact ODA at 614-728-6987 or 800-282-1955 to add a category to your license. They will send
you study guides. When you are ready to take the exam, call to schedule or go to our on-line exam registration.

The licensing year for commercial applicators is October 1st through September 30th. A commercial applicator’s license has to be renewed **each year because** it is a one-year licensure. We send a renewal for the next year to every active commercial applicator in July.

Your responsibility as a commercial applicator is to keep ODA informed of any changes to your address (i.e., moved, changed jobs, etc.). If you wish to receive the required information from ODA, we need your current address.
LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Be able to inspect for all pests that are present
- Understand inspection principals
- Insect identification
- Know the different types of inspection equipment used in pest management
- Know the benefits and limitation of pesticide application equipment

A key part of a pest management inspection is the talent of an applicator to use his skills. These skills include knowledge of pests, the tools used, and maintenance of application equipment.

A customer will see an insect on their bed and tell you, “I have bed bugs”. They will see insects in the kitchen and tell you, “I have roaches”. As an applicator you have to search for these insects, find them and correctly identify them.

You should not treat for a pest until you know exactly what that pest is. Once you have properly identified the pest, you can properly treat for it. You can then choose a pesticide that will do the best job of controlling the pest. This will make your customer very happy and you will have a continued relationship. Good customer relations will help you and your business be successful.

**Flashlight** - Though simple in form and function, the flashlight is probably the most important piece of inspection equipment in the pest management industry. Many insects, rodents, and other pests are secretive by nature. They hide in inaccessible or difficult-to-reach areas. Rarely do such areas contain enough light to expose hiding pests or evidence of their presence. Thus, a flashlight is a must in all pest management operations. When used properly, it can make the difference between successfully solving a pest problem or overlooking a critical aspect of the problem and having to make several callbacks. Select a heavy duty, waterproof and corrosion-resistant flashlight. The flashlight should be durable and provide a strong light intensity—consider halogen bulbs.

**Monitoring traps** - Monitoring traps have become one of the most important tools in structural Integrated Pest Management (IPM). These devices are tools that alert you to the severity of an insect infestation and to the location of insect hot spots. Monitoring traps can record the presence or absence of pests and/or the numbers of pests before and after a control program. This procedure assists in proving both you and the customer the overall effectiveness of the control program.

Traps are available that incorporate German cockroach pheromones (i.e., a chemical substance that will attract members of the same species to the trap). Other pheromone traps are available for various fabric and stored-product pests. As this technology advances, the industry is likely to see more pest-specific monitoring traps.

Flushing agents - A flushing agent contains an insecticide that stimulates insects. Flushing agents are a key inspection tool. They force insects from their hiding spots. In many cases, it is impossible to see into some insect habitats (e.g., hollow legs of tables, light sockets, cracks and crevices, and cabinet and wall voids). You can
determine if insects are in these places by using flushing agents.

**Hand mirrors** - A small, metal hand mirror enables you to see underneath, on top of, and behind equipment and objects. By reflecting the flashlight beam off the mirror, you can gain visual access into many out-of-sight areas, such as the inside corners of equipment, furniture, and air ducts.

**Utility tools** - A small, portable tool set containing a few types of screwdrivers and ratchets is a great utility. It allows you to disassemble various inspection plates, ventilation grills, and access panels for inspection or treatment purposes.

**Magnifying glasses** - A set of magnifying glasses would be very helpful in identifying different insects such as beetles, cockroaches, ants and termites just to mention a few. It will help in identifying exit holes, frass and debris as well.

**Miscellaneous inspection equipment** - Where permitted, cameras are useful tools for documenting situations and building conditions that you need to correct. You should keep a ladder on the truck to enable you to inspect above suspended ceilings, cathedral ceilings, and outdoor roof areas. Never use a chair or ladder that belongs to a customer.

**Moisture meters and sound detection devices** - May be useful when inspecting for wood-destroying insects, and other insects that thrive in damp conditions. Many wood-infesting pests seek wood with high levels of moisture. The sound devices can help you detect the sounds of the pest working inside wooden areas.
LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Know the different types of equipment used in pest management
- Understand particle size and how it is used
- Understand when and how to use the various application equipment
- Know when maintenance is needed
- Know how to maintain application equipment

Equipment - The ability of applicators to correctly use and maintain their application equipment is a very important process. A variety of baits, applicators, sprayers, dusters and other devices are used. Choosing the proper equipment is very important. Knowing both when and how to apply pesticides requires a high level of competency (knowledge).

High quality and dependable equipment is a necessity for pest control. Equipment used on a regular basis requires cleaning, calibration, and repair. Applicators are responsible for keeping their equipment in working order.

For an applicator to perform high quality and effective applications, he must seek uniform coverage as much as possible. An applicator loses control of the pesticide once released from the equipment. The pesticide becomes part of the environment into which it has been released (Chapter 1 Responsibility of an applicator). It may both alter or be altered by the environment. In spite of how careful and exact the applicator is in the placement of the pesticide, some of it may not reach the target. The amount of pesticide lost could depend on the application situation and the pesticide.

Particle size and the pesticide application - It is very important to understand the relationship between application and particle size. How well a pesticide works depends on the size of the droplets or particles. For example, a liquid residual application: totally wet the surface and leave a lasting deposit of pesticide when dry for control after the initial application.)

Liquid sprays range from rain-like drops to mists and fogs. These droplets are characterized by the mass median diameter (mmd) of spray. The droplets are measured in microns. This measurement is 1/1000 of a millimeter or about 1/25,000 of an inch. The average diameter of a human hair is about 100 microns.

Category of liquid applications:

- **Coarse** sprays contain droplets 400 microns or more from coarse disc nozzles or solid-stream gun nozzles.
- **Fine** sprays have droplets from 100 to 400 microns, produced with high pressure through hollow-cone and fan-spray nozzles.
- **Mists** droplet size is from 50 to 100 microns in diameter. High-pressure pumps, high-speed mechanical rotors, and atomizers produce them.
- **Aerosols and ULV fogs** are defined as assemblages of solid particles or liquid droplets suspended in air and ranging in size from 0.1 to 50 microns. By spraying the pesticides into a blast of hot air as with the thermal aerosol generator, or by mixing them with a liquefied gas they release through small orifices, as with the household total release aerosol or "bug bomb". They are also produced by atomization.
from specialized nozzles, or by being thrown off the rim of high-speed rotors.

- **Smokes and fumes**, particles range from 0.001 to 0.1 microns in diameter. They commonly produce by output of thermal fog generators. The generators use the exhaust of an internal combustion engine to vaporize the oil carrier or to partially combust the pesticide formulation.

- **Vapors** consist of airborne insecticide in droplet-sizes less than 0.001 micron.

Insecticidal dusts occur in three sizes:

- **Coarse** about 175 microns or larger, this size is to avoid excessive drift.
- **Medium** from 45 to 175 microns.
- **Fine** 44 microns or less, these droplets will pass through a 325-mesh screen.

**Sprayers** - Sprayers come in a wide range of sizes and capacities. Common elements may include tanks, pressure devices, delivery lines, cut off valves, hoses, and nozzles. In addition, other items are special accessories.

**HAND SPRAYERS**

One of the most important and frequently used types of equipment for controlling insects is the hand sprayer.

**The aerosol dispensers** Ready to use (RTU) pressurized aerosol products are available to both pesticide applicators and the general public. The containers need discarded appropriately when empty. Refillable aerosol dispensing equipment is available to pest management professionals.

The applicator can use disposable dispensers inside or outside of dwellings according to the labeling. They have a discharge valve and nozzle at the top. It also has a tube extending from the valve to the bottom. When you press the discharge valve, the gas and pesticide are then forced out through the nozzle. These dispensers can contain a variety of pesticides for a range of pests.

Some dispensers come with crack and crevice (C+C) tips for dispensing products into voids, cracks and crevices.

**COMPRESSED-AIR SPRAYERS**

The compressed air sprayer is the workhorse of the pest control industry. It is the tool most familiar to pest control applicators. More emphasis is put on monitoring, baiting, and other IPM techniques. Sprayer technology is evolving into devices designed for much more precise applications. Depending on the nozzle selection, it applies various spray patterns. Depending on the amount of pumping, it delivers the pesticide under high or low pressure as well. The applicator can use some equipment to apply foam formulation as well as liquid formulations.

You need a thorough understanding of the compressed air sprayer and its basic construction (how it works, how you can maintain the sprayer, how to make repairs to it). All this knowledge can save time, money, and prevent misapplication.

**Components**

There are three major parts to the compressed air sprayer:
The tank forms the body. The tank is made of stainless steel, brass, plastic or galvanized steel. This forms the body of the sprayer. Tank capacities range from 1/2 gallon to 3 gallons. Most professional tanks are made of stainless steel. They are resistant to the corrosive nature of many pesticides. The tank serves two purposes: the first is a reservoir for the spray mixture and the second section is a pressure chamber. There is a discharge tube attached on the inside of the tank. The air pressure inside the tank forces the spray mixture through this tube into the hose.

The pump unit consists of a pump cylinder containing a plunger rod, various soft gaskets and valves. The pump unit is hand-operated to generate air pressure inside the tank. The applicator wand made up of the valve trigger and the nozzle is connected to the tank by a synthetic rubber (usually neoprene) hose. This hose acts as the delivery tube from the tank to the applicator wand. Some wands are short, those made for wood-injection. Most sprayers today have an extension tube between the valve and the nozzle. The extension tube provides reach when applying pesticides on hard-to-get-to spots. It also helps reduce splash back of pesticides onto the applicator. Some manufacturers offer telescoping wands for convenience.

You can use the sprayer inside or outside of structures to apply residual or perimeter sprays. You can control fleas, bed bugs, cockroaches and other types of household pests with it.

The nozzle is the most important and smallest part of any sprayer. It determines the rate of spray output and the droplet spectrum at a given pressure. A good application depends on correct nozzle function. A non-adjusting
(nozzle preferred by general pest applicators) delivers a certain amount of spray per unit of time.

Nozzle systems have one or more tip types. They may include a separate spinner plate as well. Successful applications depend on the correct nozzle selection, assembly, and maintenance. Some may also have a plastic C and C applicator. Nozzle tips break the liquid into droplets. These droplets are distributed in a pattern. Nozzles control the rate of application. Nozzle performance depends on design or type, pressure, size of opening, discharge angle and distance from the target. Nozzles come in many materials. Brass is used most often. Expensive tungsten carbide and ceramic nozzles are very resistant to abrasion and corrosion. Moderately priced hardened stainless steel nozzles have good resistance to abrasion and corrosion. Plastic is moderately priced but does not last.

<table>
<thead>
<tr>
<th>5700 B&amp;G Crack &amp; Crevice Tip</th>
<th>Pin Stream Tip</th>
<th>Flat Spray Tip</th>
<th>Hollow Cone Tip</th>
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- **Pin Stream Tip**
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- **Hollow Cone Tip**
- **Solid Cone Tip**
- **Adjustable Conejet Tip**

![Figure 3.7 Image Nozzles](image)

There are six nozzle patterns usually used with compressed air application by general pest applicators.

- **Pin stream** – applies a fine stream of insecticide to treat cracks and crevices with insecticide to control cockroaches, ants, bed bugs, ticks, etc.
- **Flat fan spray** – distributes the insecticide in a thin band that applies a fan-shaped spray from the nozzle opening and is used chiefly to place residual sprays on surfaces much as a large paint brush would
- **Hollow cone** – with large hole, used for surface spraying of materials to control ticks and mites in the landscape or as perimeter spray
- **Solid cone** – is used for mosquito larviciding and area treatment of vegetation

You should normally use low-pressure application in structures. High pressure can cause the spray to go off target. High pressure causes part of the spray liquid to break into smaller droplets when it exits the nozzle. High pressure can cause splash back as well.

**Sprayer Software** - The various soft gaskets and valves contained within the application wand and pump unit is sprayer software. This software is critically important to the proper functioning of the sprayer. If sprayer software wears, breaks, or is not installed properly, it will cause a malfunction or leak. Inspect sprayer software regularly and replace worn parts immediately.

**DUSTERS**
Dusters apply a dry layer of powder mixture with a small amount of pesticide. Dust applied on porous surfaces is not absorbed as liquids are. The powder mixture lays where insects can pick it up on their hairs, legs, mouthparts, etc. The pests absorb the pesticide through the cuticle the same way as liquids. The pest can ingest particles when grooming which causes stomach poisoning. Dusts may also be inhaled through insect spiracles.

**Foot Pump** – This is a hand-operated plunger type blower with a container for insecticide dust. A stirrup is provided so you can hold the pump down with one foot. The operator pumps air and insecticide through a hose to the treatment area. You use this tool to apply dust to rodent burrows and other enclosed shelters.
**Bulb Duster**
A bulb duster is a rubber bulb with a screw cap cover. This type duster is fitted with a dust nozzle. The dust is distributed by squeezing the bulb. These dusters are used in the same situations as the hand bellows dusters.

**Hand Bellows**– This is a rubber cylinder (height 3”) with a metal top and bottom. The top has an opening fitted with a cap. The bottom has a metal extension tube. A large coil spring touching both the top and bottom supports the device inside. You put the dust inside the cylinder from the top. After you insert the cork, dust is blown through an extension tube by hand pressure on top and bottom. You use this tool for dusting crevices where cockroaches and silverfish hide. You can use it for placing a small amount of rodenticide in voids for mouse control.

**Power Dusters** – A variety of dusters operate by means of electric-powered pumps, which pressurized the pesticide dust contained in the reservoir. Pumps may utilize electricity from 110-112 v. AC power outlets or they may be battery powered.

**Rodent Bait Box** - Bait stations are devices that keep rodenticides and traps safely out of reach of non-target animals. Some have lock down lids and tie down straps or pegs that help prevent children from moving boxes or touching rodent baits. You can use rat and mouse bait stations indoors and outdoors. Many food-processing plants, restaurants and other businesses located near food-oriented stores and restaurants will use these devices as well. Keeping a constant supply of outdoor bait around buildings gives unwanted rats and mice a chance to feed on rodent baits before they have a chance to enter buildings.

Choose the correct bait station for your situation and rodent problem. You can also choose bait stations that safely house the traps or baits used in your rodent control program. These boxes will hold glue traps as well.

Exterior rodent bait stations usually come with hardware to hold bait inside. They should also be securely anchored using stone pavers or anchoring stakes.
LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Know when to calibrate your equipment
- Understand how to calibrate your equipment
- Know how to use time as a calibration tool
- Learn formulas for calibration

EQUIPMENT CALIBRATION

Why Calibrate Spray Equipment
Calibration is a process of measurement. You measure the solution that comes out of the equipment during a certain period. A pest control applicator should know that the proper dosage of pesticide is applied. Without accurate calibration of sprayers, the amount of pesticide delivered will be incorrect.

Over dosage will contaminate the spray area. Less than recommended dosage might fail to control the pest. Applicators need to look regularly at the output of their equipment. Flow meters are very helpful to let the applicator know the output of the sprayer over time.

- The estimated number of sprayers that have a 10% calibration error is 60 percent.
- A large percentage of sprayers have greater than 10 percent variation in discharge from individual nozzles or tips.

How to Calibrate Equipment
Calibration does not have to be a difficult process. It can be as simple as reading a pesticide label for the mixing instructions. It can be as simple as the time it takes to spray an amount of liquid and then measure that amount. This will determine how much liquid is expelled from the sprayer during a period.

The nozzle flow rate determines the spray applied per unit area. The flow rate through a nozzle varies because of pressure in and size of nozzle. Using a nozzle with a larger opening will increase the flow rate.

Increasing the pressure will not increase the flow rate. You cannot use pressure to make major changes in spray rate. It can however, make minor changes.

The most effective way to make a large change in flow rate is to change the size of the nozzle tip. Depending on the pressure, small changes in nozzle size can change the sprayer output. You can use nozzle catalogs to select the proper tip size.

Nozzles with multiple different nozzle sizes on one tip should be calibrated. Calibrate each tip if the nozzle has four different tips then calibrate each tip separately.

Liquid Application on a Percentage Basis - The amount of active ingredient (a.i.) for structural insect control recommendations is usually in percentages. The pesticide manufacturer normally provides a spray dilution chart on the label. This chart lists the amount of formulated product that needs to be mixed with various quantities of diluent (usually water). This mixture provides the desired spray mixture. Thus, insecticide mixtures can be prepared directly from label directions without the need for calculations.

Liquid Application and Calculations – You should conduct sprayer calibration using tap water or base oil. Calibration depends on the formulation applied and equipment used. After you have properly calibrated your equipment, it is ready to use. The next step is to read the label and find the site and pest which you are treating. Then mix the pesticide and the diluent together in the sprayer tank. Put the lid on the sprayer and tighten it. Get a large bucket and spray the pesticide liquid into the bucket. Keep the time on how long you sprayed the liquid into the bucket. Measure the liquid in the bucket.

EXAMPLE: (Time of spray = 10 minutes)
(Area sprayed = 600 sq ft)
(Accumulation of pesticide = 1 pt)
FORMULA: (Timed spray x Area sprayed x Accumulation of Pesticide)

EXAMPLE QUESTION: You are performing a flea treatment with the same calibration information as above. It takes the applicator ½ hour to do a flea treatment in a ranch house. How much solution is used and what is the square footage of the house?

CALCULATION: Change hours to minutes ½ hour to 30 minutes

30 minutes ÷ 10 minutes = 3

3 X 600 sq ft – 1800 sq ft
3 X 1 pt = 3 pts of solution
LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Understand why certain arthropods and vertebrates are considered pests
- Understand the concepts of ecosystem, community, and population as they apply to management of structural pests
- Be able to relate to the sequence of methods and activities involved in a pest control situation
- Be able to recognize the components of integrated pest management (IPM)
- Understand the concept of pest thresholds
- Understand the concept of resistance, how to recognize it, and possible ways to manage it

WHAT ARE PESTS?

Pests are not pests because of what they are (bed bug, yellow jacket) but because of what they do (suck blood, bite or sting) and where they are found.

According to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), a pest can be any insect, rodent, fungus, or weed as well as other organisms. Most simply defined in The Dictionary of Pest Control, a pest is “Any unwanted organism.” Pests of structures can be generally characterized as organisms (excluding parasitic microorganisms) that have human health, economic, or aesthetic implications, or that damage wooden support structures of buildings (covered under Category 10b—Wood-Destroying Pests). Unlike agricultural pests, they are less likely to cause direct economic damage to products.

For instance, cockroaches or rodents may cause an economic hardship when restaurants or food-packing plants have to close by legal action. The action is taken for human health reasons. Likewise, carpet beetles in woolens or museum tapestries degrade clothing or works of art. The reduction of value of the pieces is primarily for aesthetic reasons rather than consumption of woven wool.

**Ecosystem** - Pests occur as a group or population of individuals of a particular kind. They are defined by the way they behave in that environment or ecosystem. The different populations that exist together are a community. One such community may be fleas, pets, and people. A community together with its physical and biological supporting factors makes up the ecosystem (e.g., German cockroaches, fleas, people, pets, and their required food, shelter, and water). The applicator does not look at the pest infestation alone but must consider all elements in the ecosystem to design the best control and management methods.

METHODS OF PEST CONTROL

**Pest management** means the reduction of pest populations to tolerable numbers by changing practices, making habitat or structural alterations, and carefully using pesticides to kill pests only when indicated. Many variations and combinations of methods are used to control pests, but the sequence of these methods follows a pattern: inspection, habitat alteration, pesticide application, and follow-up.

**Inspection** - Pests do not infest uniformly—they focus on specific areas. These pest-preferred sites must be understood and located. Training and experience in conducting inspections are important for successful location of infested areas.

**Habitat Alteration** - Infested areas provide harborage, (i.e., a place that provides an organism’s food, water, and shelter requirements) for pests, so changing or eliminating some of these favorable elements will make survival less successful. Such changes commonly include increased sanitation, moisture reduction, and the elimination of clutter.
Pesticide Application - Though successful habitat alteration can reduce or eliminate populations, it will often be less than complete and pesticide application may be necessary. The key to pest control is the successful combination of these methods.

Follow-up - Follow-up practices such as detailed record keeping, supervisor oversight, and a quality control program can make the difference between the success and failure of a pest management program.

Routine Pest Control - In routine pest control, a technician follows a preestablished schedule or route to:
- Make expected appearances
- Make inspections
- Apply appropriate controls
- Talk with the tenant or manager
- Record information required by law

Though the inspection can indicate where pests occur, with this approach, pesticides are usually applied regardless of whether pests are observed or not. Those who practice this approach are satisfied that pests will be killed as they contact the pesticide residue.

Disadvantages
- Time alone governs the schedule
- Inspections are brief
- Boredom from repetition can affect the technician
- Pesticide use regardless of whether there is an infestation
- There is no evaluation
- Records are brief
- Long-term solutions are not provided

Corrective Pest Control - In corrective pest control, a technician responds to special, unscheduled calls and:
- Talks with clients
- Makes an inspection
- Identifies infested sites
- Harborage modification
- Methods to reduce pest food, water, and harborage, such as sanitation, maintenance improvements, habitat alteration, etc.
- Applies pesticides to pests or sites
- Records necessary information required by law

Advantages
- Response is relatively quick
- The occupant is satisfied by the fast response and immediate pest suppression
- The interaction with technicians is positive
- Minor recommendations by the technician to clients are often accepted because the client requested them. Such recommendations make pest control more effective
- Situations are more interesting for technicians, and it reduces boredom

Disadvantages
- Clients often mistakenly assume complete extermination
- Clients are quick to anger if the problem reoccurs
- Without a detailed inspection, failure is likely
- If pests are not found then pesticides are often used as barriers
- This approach is less economical than scheduled, route-type responses
- Records are brief

Discussion - A higher level of technical expertise and a better ability to interact with clients are needed for reactive than for preventive pest control. A quality control program will reinforce technician recommendations.

Pest Elimination or Pest Extermination
- A senior technician responds to an appointment, and:
  - Interacts with clients
  - Makes an intensive inspection
  - Applies pesticides in a variety of formulations each time
  - Makes follow-up inspections
  - Records information on past inspection and recommendations as well as information required by law

Advantages
- Significant interaction with the pest control applicator gives the client a good understanding of the problem and the changes needed for control
- The pest control applicator interacts directly with clients
- Longer-lasting control results from changes made by the client
- Thorough pesticide application occurs
- There is a high level of interest by technicians

Disadvantages
- Mistakes in inspection and recommendations to clients or subsequent lack of follow through by clients will result in control failure
- A maximum amount of pesticides is usually used; chances of potential misuse, misapplication, and pesticide accidents are increased
- High pesticide and labor costs are sustained
- Unexpected results are quickly noticed and questioned
- The energy required to completely eliminate a pest population is much greater than that required to keep a pest population suppressed to a tolerable level

Discussion
You need a high level of technical expertise as well as superior ability to get client cooperation.
INTEGRATED PEST MANAGEMENT (IPM) COMPONENTS
You should consider and integrate pest management components and overall pest management plan.
You should emphasize monitoring and record keeping inspections, continual sampling, and use of survey devices that result in accurate recorded pest counts. You need to monitor identified zones of potential infestation and intensified search in infested target sites. You need to place record books or logs in central areas or management units. Records contain monitoring counts; sanitation, maintenance and personnel practice problems; pesticide use, formulations, and amounts. Keep the records accessible to applicator, supervisors, and clients.

Education, Training, and Communication -
Communication is an on-going activity. The applicator should reduce the pests to a level the client would accept. To achieve these goals, the pest technician interacts actively with the client. On-going informal training or instructive communication between the technician and the client or designees is important. Pest management supervisors, technical representatives, or consultants provide formal training.

Designees are clients with whom pest management technicians will review the records, problems, and control programs each monitoring or treatment interval. Liaisons are intermediaries between the clients and the pest control company. They should explain the pest management program to other clients (i.e., staff members, tenants, workers, etc.) Designees coordinate client efforts needed for the success of the program.

Integrated Control Methods - The applicator should consider all practical measures to suppress the pest population to a tolerable level:
- Cultural controls (e.g., regular cleaning schedule, garbage elimination, changes in worker procedures)
- Physical modifications and maintenance changes (e.g., screening, caulking, etc.)
- Pest control devices and pesticides

Thresholds - A level at which pest can be tolerated is a threshold. Integrated pest management is site-specific. Different numbers of cockroaches are tolerated at different sites (e.g., hospitals vs. garbage rooms). The number of pests that can be tolerated at each target site is determined (this level may be zero). Setting thresholds eliminates preventive spraying, curtails excessive pesticide application, and encourages good inspection. Some sites tolerate higher pest numbers than others.

Evaluation, Quality Control, and Reporting - No gains can be made in pest management without an evaluation. You should schedule times for interviews, surveys, and record examinations. Persons other than the applicator should conduct the evaluations. Client management should receive formal written and verbal reports made at scheduled intervals by technical representatives or pest management supervisors.

A CASE FOR IPM: RESISTANCE
Some insects become resistant to a pesticide, and the most complete application cannot achieve acceptable control. Of structure-infesting pests, the housefly and the German cockroach demonstrate the most significant resistance to pesticides.

How Pests Become Resistant to Pesticides –
Physiological resistance - Most pesticides are put together by combining chemical elements. Large pest populations have some individuals whose internal systems can reduce (break down) the pesticide compound to harmless elements. When the pesticide is applied, these pests survive. They produce some offspring that can also break down the pesticide.

Behavioral resistance - This form of resistance describes the ability of some members of a pest population, and their offspring to avoid lethal exposure to pesticides. With each generation, more and more offspring inherit resistance. If applicators continue to apply that pesticide, more and more will be able to survive a pesticide application. Once present, genes for resistance are always carried by some members of the population.

How to Recognize Resistance - First, eliminate reasons that lead to failure of population suppression. If the questions below are answered positively and the pests still exist, it may be a resistance problem. You may need to test for resistance:
- Are clients doing their job by improving sanitation, reducing clutter, etc.?
- Have inspections been complete?
- Have pests been correctly identified?
- Has habitat alteration been complete?
- Have pesticides been applied accurately?

The Way to Prevent Resistance - Using the same class or same pesticide to control pests can lead to resistance. Use pesticides from different classes and groups. Use alternating pesticides with different modes of action. This type of action can also reduce the development of resistance.
LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Understand why different types of facilities require special pest management considerations
- Understand the federal and state laws that affect pest management in food handling and other specialized facilities
- Know which areas to inspect for proper sanitation in food handling establishments
- Know which types of facilities require specialized integrated pest management (IPM) programs
- Know the key pests and the specialized pest management techniques required for each type of facility
- Understand the importance of on-going communication, monitoring, record keeping, and follow up when managing pests in specialized facilities
- Understand the requirement of facilities that are National Organic Program (NOP) certified

This chapter discusses some of the specialized facilities requiring customized pest management techniques. These facilities include supermarkets, schools, health care facilities, zoos, pet shops, and computer facilities. There are many other specialized facilities not discussed in this chapter, such as shopping malls, resort hotels, museums etc. These facilities also require pest management programs tailored to their needs.

Pest management in food handling and other specialized facilities requires special consideration because of:
1. The types of pest problems involved
2. Certain unusual medical or aesthetic requirements
3. Unique structural features of the facilities
4. Presence of very favorable conditions for pests because of the type of work or operation involved.
5. Limitations of what pest management techniques can be used

In all pest management situations, it is critical to be familiar with the state and federal laws governing pesticide use. It is very important to follow pesticide label directions precisely. A properly designed pest management program must include the basic steps of inspection, communication, continual follow up, and treatment (or application of pest management procedures).

PEST MANAGEMENT IN FOOD HANDLING ESTABLISHMENTS

Commercial food establishments must comply with the high standards enforced by various government agencies. Sanitation standards are enforced by the Food and Drug Administration (FDA) and pesticide regulations enforced by the Environmental Protection Agency (EPA). Food handling establishments are defined as an area or place other than a private residence in which food is held, processed, prepared, and/or served. *(Held* includes displayed for sale as well as stored.) Included are such places as restaurants, bakeries, grocery stores, cafeterias, school lunchrooms, food-processing plants, food storage areas, etc.

**Laws and Regulations** - All food processors are subject to the federal Food, Drug, and Cosmetic Act of 1938 (FD&C Act) and its subsequent amendments. It is a violation of federal law if manufactured food products contain any objectionable extraneous matter. This means that action can be brought against a food processor (and even against the pest management company servicing the operation). If insects or other potential sources of contamination are found in or near equipment, ingredients, or finished products enforcement action will be taken. If the potential for contamination exists, the product may be deemed contaminated. Food processors are expected to follow the good management practices.
potential or existing problems. This allows steps to be taken to prevent or correct problems before regulatory inspectors detect them or before complaints are received from customers. Some areas to inspect for real or potential pest problems in food handling establishments follow.

**Exterior area**
- Pest harborage under objects lying or stored directly on the ground
- Garbage-handling systems (storage, containers, cleaning methods, and trash handling)
- Proper drainage
- Weed control (Weeds provide both food and harborage for insects and rodents.)
- Perimeter rodent control
- Perimeter insect control
- Surrounding environment (any surrounding areas or buildings conducive to pests)
- Rodent, insect, and/or bird proofing
- Proper lighting

**Interior areas**
- Wall and floor maintenance (Are cracks sealed and floors clean?)
- Ceilings (Do they leak or provide harborage areas?); suspended ceilings are particularly suspect
- Elevator shafts
- Floor drains (Are they clean?); cover plates and catch basins must be removed during inspection.
- Plumbing (Are areas where pipes come through walls rodent proof?)
- Condensation (Does it provide a breeding area for flies or other pests?)
- Lighting (Do lights attract insects into the building?)
- Doors (Are they in good repair and shut tightly and do personnel observe door-closing policies?)

**Storage**
- Proper stock rotation practices (e.g., first in, first out)
- General housekeeping (Are spilled products cleaned up?)
- Empty containers
- Segregation of damaged goods
- Refrigeration storage

**Food preparation areas**
- Housekeeping around equipment
- Cleanliness of counters and preparation surfaces
- Storage practices (Are food items kept in tightly sealed containers, etc?)

**Lockers and rest rooms:**
- General sanitation
- Lockers well-organized and not accumulating food trash

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**Sanitation and Inspection** - Sanitation is the most important aspect of pest management in food handling facilities. Food processing plants are subject to FDA or USDA sanitation inspections, depending on the type of facility. The pest management professional should be aware of the problem areas that FDA or USDA inspectors look for. Pest control technicians must conduct a thorough inspection of the facility and notify the plant manager of potential or existing problems. This allows steps to be taken to prevent or correct problems before regulatory inspectors detect them or before complaints are received from customers. Some areas to inspect for real or potential pest problems in food handling establishments follow.

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- Segregation of damaged goods
- Refrigeration storage

**Food preparation areas**
- Housekeeping around equipment
- Cleanliness of counters and preparation surfaces
- Storage practices (Are food items kept in tightly sealed containers, etc?)

**Lockers and rest rooms:**
- General sanitation
- Lockers well-organized and not accumulating food trash

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**Sanitation and Inspection** - Sanitation is the most important aspect of pest management in food handling facilities. Food processing plants are subject to FDA or USDA sanitation inspections, depending on the type of facility. The pest management professional should be aware of the problem areas that FDA or USDA inspectors look for. Pest control technicians must conduct a thorough inspection of the facility and notify the plant manager of potential or existing problems. This allows steps to be taken to prevent or correct problems before regulatory inspectors detect them or before complaints are received from customers. Some areas to inspect for real or potential pest problems in food handling establishments follow.

**Exterior area**
- Pest harborage under objects lying or stored directly on the ground
- Garbage-handling systems (storage, containers, cleaning methods, and trash handling)
- Proper drainage
- Weed control (Weeds provide both food and harborage for insects and rodents.)
- Perimeter rodent control
- Perimeter insect control
- Surrounding environment (any surrounding areas or buildings conducive to pests)
- Rodent, insect, and/or bird proofing
- Proper lighting

**Interior areas**
- Wall and floor maintenance (Are cracks sealed and floors clean?)
- Ceilings (Do they leak or provide harborage areas?); suspended ceilings are particularly suspect
- Elevator shafts
- Floor drains (Are they clean?); cover plates and catch basins must be removed during inspection.
- Plumbing (Are areas where pipes come through walls rodent proof?)
- Condensation (Does it provide a breeding area for flies or other pests?)
- Lighting (Do lights attract insects into the building?)
- Doors (Are they in good repair and shut tightly and do personnel observe door-closing policies?)

**Storage**
- Proper stock rotation practices (e.g., first in, first out)
- General housekeeping (Are spilled products cleaned up?)
- Empty containers
- Segregation of damaged goods
- Refrigeration storage

**Food preparation areas**
- Housekeeping around equipment
- Cleanliness of counters and preparation surfaces
- Storage practices (Are food items kept in tightly sealed containers, etc?)

**Lockers and rest rooms:**
- General sanitation
- Lockers well-organized and not accumulating food trash
Vending machines
- Machine cleanliness
- All areas beneath and behind machines

Utility areas
- Not being used as overflow storage areas
- Out-of-sight corners of floors and ceilings

Figure 6-1 The sanitation professional must inspect all areas of the food plant.

Insecticides in Food Handling Establishments -
Insecticides applied in food handling establishments must not contact or contaminate food products. It is important to distinguish the food and non-food areas. Non-food areas may include locker rooms, lavatories, machine rooms, boiler rooms, rubbish rooms and garages. These areas are where food is not normally present. Food areas include any location where food is stored or processed. Restrictions apply to the types of insecticides and treatments that can be used in food or non-food areas. The product label has the information and details on what products can be used in these establishments.

Residual Insecticides are products, which effects last several hours or longer. There are four types of residual applications: general, barrier, spot, and crack and crevice. Each can be used in areas of food handling establishments as directed by the product label.

General treatment is a broad expanse application to inside surfaces such as walls, floors, and ceilings, or outside treatments. This type treatment is for non-food handling areas only. Only pesticides registered for this use may be used.

Barrier treatment is the application of pesticides to thresholds, entrances, foundations, and nearby soil.

Barrier treatments with residual sprays, dusts, or granules control outdoor pests that may become invaders or nuisances when their numbers increase.

Spot treatment is application to small areas where insects walk but will not contact food, utensils, or workers. Such areas are on floors, walls, or bases or undersides of equipment. Spot treatments should not exceed 2 square feet. In many cases, spot treatments are only allowed in non-food areas. Check the label to be sure of the proper use of spot treatments.

Crack and crevice treatment is the application of small amounts of pesticides into cracks and crevices that pests use to enter buildings. These commonly occur at expansion joints. They occur between equipment and floors. The openings may lead to hollow walls, equipment legs and bases, conduits, motor housings, or junction or switch boxes. You can use liquids, dusts, or baits for crack and crevice treatments. These products can be used in food areas if the pesticides are placed into cracks and crevices.

Residual pesticides may be applied when food establishments are in operation unless the product label prohibits it.

When using non-residual pesticides (effects only during the time of treatment) as space treatments (aerosol, ULV and fog), the application should be made when the establishment is not in operation and foods are removed or covered. Food handling surfaces should be cleaned before use.

Rodenticides in Food handling Establishments -
Rodenticides are applied in attractive food or as liquids. Baits usually require “tamper resistant” containers that are designed to protect animals and children. The bait containers protect food from contamination as well. You need to pay special attention when placing bait stations.

Pest Management for Supermarkets - A supermarket is an example of a food-handling establishment. The flow of food and other materials is enormous. Stores like this are centers of intense activity. Food and supplies funnel in from many sources and are dispersed widely into the community. State and local public health officials and other regulatory agencies (e.g., FDA and USDA) inspect supermarkets.

Any presence of pest infestation can be detrimental to the store’s reputation and business. Due to frequent pest introduction on incoming shipments, the presence of several key pest “hot spots” and the need for constant attention to sanitation, a very organized program will be required to achieve the desired level of pest management.
Fig 6.2 Large modern supermarkets are complex structures through which enormous amounts of food and many store customers flow each day (Whitmore/Micro-/Gen)

**Key Pests**
- Cockroaches
- Mice and rats
- Flies, especially fruit/vinegar flies (*Drosophila* spp.) around produce
- Stored-product insects
- Birds (outdoors and sometimes indoors)

**Pests Hot Spots**
- Delicatessen sections
- Bakeries
- Restaurant areas
- Meat departments
- Under and behind shelves
- Pet food aisles
- Natural food bins
- Fruit and vegetable (produce) aisles
- Bottle return and storage areas
- Employee locker rooms
- Dumpsters and other trash areas

**During Inspections**
- Routinely check receiving areas for incoming stock
- Use sticky traps routinely to monitor for pests in key areas
- Monitor sanitation problems; report them to appropriate staff, and check follow-up

**During Pesticide Application**
- Make sure that products are properly labeled to be used in schools or daycare centers
- Avoid any possibility of contaminating food or any food-contact surfaces
- Always read the product label and remember that most of the store is considered a food area (examples of non-food areas would be bathrooms, locker rooms, etc.)

**Other Points**
- Work with store management to correct chronic problems with infested incoming stock
- Be sure that the quick and complete cleanup of all spills is routine through the facility
- Check that spilled food and other clutter have not collected under, behind display shelves, or in corners. Focus attention on these dead areas when inspecting and treating
- Remember that the meat department falls under the guidelines of USDA meat and poultry regulations and is inspected by USDA inspectors

**Pest Management in Schools and Day-Care Centers**
Pest control in schools and day-care centers must protect the health and safety of the children and staff. Structures and property should be protected to minimize pest damage as well. In addition, the quality of the educational environment will be improved by avoiding annoyances and disruption of work and learning caused by pests. The success of an IPM program in schools depends on communication and cooperation. All affected parties must communicate and cooperate with one another. The pest management professional’s role in the school IPM program is to:
• Develop an effective IPM program based on prior training, experience, and knowledge of pest biology
• Perform the actions needed to control pests and to inform others of actions they should take to control pests
• Keep administrators and staff informed on all pest management decisions and operations
• Continually monitor the site and the pest population to determine if the actions taken were successful

Some key points in managing pests in schools follow.

Key Pests
- Cockroaches
- Ants
- Mice
- Flies
- Stinging insects

Pest Hot Spots
- Lockers and desks
- Break rooms
- Janitorial closets
- Cafeteria areas (kitchens, storerooms)
- Vending machine areas
- Trash dumpsters and related facilities

During Inspections
- Work routinely with floor diagrams and checklist
- Develop reporting sheets for administrative and custodial employees to use in reporting pest sightings
- Educate and build relationships with staff to gain their assistance
- Inspect for pest problems associated with the plumbing system (floor drains, sinks, bathrooms). Identify areas where there is standing water and/or wet or water-damaged materials
- Arrange for inspection of desks and lockers for leftover food, beverages, gum underneath desks, etc.
- Check science labs for cleaning of animal cages and storing of animal feed in tightly sealed containers
- Check to see that indoor plants are kept healthy and free of pests. Plants requiring application of an insecticide should be removed to an unoccupied location
- Look for areas of paper clutter and inadequate trash removal. Are recycling areas (soda cans, papers, etc.) kept clean and materials sorted in adequate holding bins?
- Inspect outdoor play areas for stinging insect nests

During Pesticide Applications
- Make sure that products are properly labeled to be used in schools/day-care centers
- Consult the product label when insecticide applications in schoolrooms/day-care centers are performed. It may be best to arrange pesticide applications on days on which the school or day-care center is officially closed
- It is the pesticide applicator’s responsibility to notify the school’s/day-care center’s building manager of the period for reentry
- Stress use of tamper-resistant bait stations wherever appropriate. Baits and crack and crevice formulations are considered less hazardous than sprays and foggers (i.e., they pose less risk of pesticide exposure for school occupants).
- Keep detailed and accurate records (type of pesticide used, amount, location, time and date of use, etc.) of all pesticide applications

Other Points
- Encourage school administrators and staff to inform students about policies regarding sanitation/prevention (e.g., allowing food items only in designated areas, not storing food in lockers and desks, wrapping or bagging food waste before disposal, not placing gum under desks, and reporting pest problems to teachers)
- Set action thresholds for each pest. Action thresholds are set by determining how many pests can be tolerated by school occupants before action is taken (for example, applying a pesticide) to control the pest. Continuous monitoring with bait stations and traps helps to establish action thresholds
- If head lice are a problem, advise administrators to consult the local health department and have parents contact a physician. Children should be discouraged from exchanging hats and caps at school.
- Pest Management in Health Care Facilities includes hospitals, long-term care facilities (nursing homes), emergency medical-care centers, and physical or mental rehabilitation facilities. These facilities vary in size from just a few beds to hundreds. Each type of facility will have similar pest management requirements although size will affect the complexity of the pest management effort. Pests can not be tolerated in health care facilities, not only for aesthetic reasons but also for important medical reasons. For example, many common hospital pests carry bacteria inside or on the surface of their bodies that can cause infections among patients either directly (i.e., by encountering skin wounds) or indirectly (i.e., through contamination of hospital food or medical supplies). According to regulation, a detailed
IPM plan is also required for pest management in health care facilities. Key points for management of pests in health care facilities follow.

**Key Pests**
- German and brown-banded and American cockroaches
- Ants (especially pharaoh ants)
- Mice
- Flies (especially associated with drains and decaying materials)
- Stored product pests

**Pest Hot Spots**
- Employee locker and break rooms
- Janitorial closets
- Food service areas (kitchens, storerooms)
- Restaurants and snack bars
- Vending machine areas
- Food carts
- Bedside furniture in patient rooms
- Floor drains and sink areas
- Intensive care wards
- Surgical suites
- Kidney dialysis rooms
- Autopsy rooms
- Trash dumpsters and related facilities

**During Inspection**
- Work routinely with floor diagrams and checklists
- Develop reporting sheets for nurses and other employees to use in reporting pest sightings. Educate and build relationships with staff to gain their assistance
- Inspect for pest problems associated with the plumbing system (floor drains, sinks, bathrooms, scrub-down areas, autopsy rooms, laundry areas, etc.)
- Do not overlook locked janitorial closets and employee lockers

**During Pesticide Applications**
- Always check with the head nurse or person in charge before treating in-patient care or other sensitive areas
- Patients should not be present during any pesticide applications or until all vapors and odors are gone. Coordinate with the nursing staff to have patients moved
- Consult label to determine patient restrictions and reentry times.
- Use low-odor or odorless residual insecticide formulations as crack and crevice or limited spot applications only
- Do not allow sprays, mists, or dusts to become airborne
- Use bait formulations wherever appropriate
- Be careful with pesticides around sensitive electronic or medical diagnostic equipment
- Keep detailed and accurate records of all pesticide applications

**Other Points**
- Always maintain a clean, neat appearance and highly professional approach around nurses and other medical staff. You will need their respect and assistance
- Work closely with the infection control, housekeeping, maintenance, food service, and nursing staffs on sanitation and reporting of pest sightings.
- Do not discuss sanitation problems or other aspects of the pest management program in the presence of patients or visitors, or where they might overhear
- Pest Management in zoos and pet stores represent a difficult challenge for pest management professionals. Pests such as cockroaches, rodents, and flies can be responsible for spreading bacteria or other parasites that cause infections and diseases among pet store and zoo animals. Zoos and pet stores often provide favorable harborage for pests. Food is constantly available. Zoos can be very complex structures with underground tunnels that house steam pipes and other utility connections to different buildings through which pests can travel. Some points to consider when managing pests in zoos and pet stores follow.

**Key Pests**
- Cockroaches (several species)
- Mice/rats
- Flies
- Birds
- Wasps and yellow jackets

**Pest Hot Spots**
- Voids in walls, display boxes, and indoor signs
- Electric conduits, light fixtures, and switch or circuit breaker boxes
- Trash receptacles
- Snack bars and employee locker rooms
- Animal diet preparation areas and feeding areas
- Animal display enclosures
- Floor drains
- Steam tunnels

**During Inspections**
- Be alert near animals
- Pests associated with manure and outdoor display areas can move indoors
- Spot opportunities for effective caulking and pest exclusion
• Note correctable sanitation problems and work with the staff

**During Pesticide Applications**
• The use of bait formulations is preferred, but place them carefully
• Do not apply pesticides into the air around sensitive animals
• Use crack and crevice or limited spot applications with residual insecticides. Use wettable powder, concentrated suspension, or microencapsulated formulations for longest residual action
• Dust voids that will stay dry for pest control and as an exclusion technique
• Be careful of possible secondary pesticide poisoning risk to zoo animals feeding on treated pests.

**Other Points**
• Always cultivate working relationships with zookeepers/staff
• Inform zookeepers/staff about any pesticide applications made
• Before using any pesticides, discuss applications with the staff to determine sensitive animals and other concerns

**Pest Management in Computer Facilities** - Computer facilities such as computer rooms in banks and scientific laboratories, and large control rooms at electrical power plants, airports, or large modern factories represent a special pest management challenge. Insects walking across computer circuitry can cause short circuits and other serious problems. Fecal droppings and other body secretions of pests can also damage sensitive electronic circuitry. Special difficulties arise in these facilities because professionals are restricted in the types of pesticide applications they can make around such sensitive and valuable equipment. Professionals are often faced with these treatment restrictions when pests infest computers, cash registers, telephones, smoke detectors, or other electronic equipment. Use of baiting and traps rather than sprays or dusts is often recommended in these sensitive areas.

**Key Pests**
• German or brown-banded cockroaches
• Mice
• Ants
• Flies and gnats

**Pest Hot Spots**
• Areas where employees consume or store food in the facility
• Break rooms or vending machines
• Coffee machines
• Inside computer equipment that offers a warm harborage for pests

• Above drop ceilings or below raised floors

**During Inspections**
• Keep in mind that renovations to the facility may have created hidden voids or passageways for pests

**During Pesticide Applications**
• Do not apply sprays or dusts into computer equipment or in such a way that droplets or particles can damage sensitive circuitry
• Use baits and traps rather than sprays and dusts
• Apply liquid residual applications safely by painting material on with a brush

**Other Points**
• Encourage facility management to prohibit any food (storage or consumption) within the facility
• Be particularly thorough with standard pest management efforts in areas of the building adjacent to the sensitive computer facility to create a pest free buffer zone around the facility.
LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Know the common characteristics and the various classes of “arthropods”
- Understand how divisions are used in insect classification
- Know the different stages of insect growth and development
- Understand why knowledge of insect growth and development is an important pest management consideration

Ancestors of insects were the first animals to move onto land. As plants developed, insects did as well. The developing insects fed on the developing plant life.

At the time of the early insect development, the land had a uniform climate. A climate with enough moisture and adequate temperature for constant growth. Later the surface land started shifting and breaking apart. Some parts shifted north or south and some shifted east or west. This shifting created the different climates and set the stage for the world, as we know it today.

INSECTS AS PART OF THE ANIMAL KINGDOM

Living things are divided into the plant kingdom and the animal kingdom, and several smaller kingdoms of microscopic life. Insects are part of the largest group in the animal kingdom—the phylum Arthropoda. In this group, arthropods include spiders, mites, ticks, millipedes, centipedes, crabs, shrimp, isopods, and insects.

Phylum Arthropoda - An arthropod has:
- A body made of segments that are grouped or fused together
- Legs, antennae, and other appendages attached in pairs
- A hard or tough external covering with some pliable or soft parts. This hard outer covering holds the body together and gives it shape. It performs the same function as the mammal’s bony internal skeleton and is called an exoskeleton.

Principal classes of arthropods are:

- **Arachnida** - This class includes spiders, mites, scorpions, daddy longlegs and others. These arthropods usually have mouthparts and two prominent structures that end in needle-like piercing tips. They have four pairs of legs and two body regions. Arachnida mouthparts and legs are attached to their first body region. The reproductive organs and digestive system are contained in the second body region.

- **Crustacea** - This class includes aquatic crabs, lobsters, and shrimp. This class includes crustaceans that dwell on land isopods, which include as well pillbugs, and sowbugs.

- **Myriapoda** - This group is made up of two classes: millipedes and centipedes. The millipedes have many segments and are worm like. They are more in cross section, round with short antennae and have two pair of legs per segment. Centipedes also have many segments and are worm like. They are more flattened and have only one pair of legs per segment. Their antennae and hind legs are long. All the legs of the house centipede are very long.

- **Insecta** - This class contains the insects: arthropods with three body regions. These regions are the head, thorax, and abdomen. The head bears a single pair of antennae. The thorax bears three pairs of legs and usually the wings. The abdomen contains most of the digestive system and reproductive organs.
Other Divisions Used in Classification
Classes of arthropods, insects, for example, are divided into orders. These are distinct groups whose members look very much alike (e.g., moths and butterflies or beetles).

Orders are subdivided into families made up of related species. Species of animals can be thought of as specific kinds. Very closely related species are grouped together in a genus. Species or types of animals are given scientific names that always consist of two words. The first word is the genus name (the first letter is always a capital). The second word is the species name (always lower case). Both are written in italics or underlined (e.g., Musca domestica or Musca domestica). Well known species also usually have non-scientific names called “common names” (e.g., housefly).

GROWTH AND DEVELOPMENT

Growth
The arthropod body is confined in its exoskeleton. This outer covering can expand only a little in as pliable or soft places. It does not grow continuously. Insects grow in stages called instars. An instar is any stage of an insect between molts for example different stages of larvae, nymphs, and pupae. Insects form each new soft exoskeleton under the old one. Then they shed or molt the old one. The new skeleton is larger and allows the animal to grow. The new exoskeleton is white or lighter colored at first. As the skeleton hardens, it darkens in a few hours. After the molting process, that takes place in hiding, normal activities are resumed.

Development - Most arthropods hatch as tiny individuals and grow by molting. These arthropods usually keep the same appearance until they become adults. However, a spectacular important exception occurs in the class Insecta. The insect class is divided into groups according to the way insects change during their development. This change is called metamorphosis. Metamorphosis means, “Change in form”. Three main types of metamorphosis have been identified.

Group 1. Simple Metamorphosis - This group includes the order of the silverfish. The silverfish makes no drastic change in form from young to adult. They simply hatch and grow larger by molting. There are only a few orders included in this group.

Group 2. Gradual Metamorphosis - Some insects in this group are cockroaches, crickets, grasshoppers, box elder bugs and earwigs. In this group, individuals hatch from the egg only partially resembling the adults. The young or nymphs do not have wings but may have wing buds or wing scales. Winged insects are usually adults. Fourteen orders develop this way. Some of these orders have many species and include many pests. Nymphs and adults are often found together and usually eat the same food.

Group 3. Complete Metamorphosis - Insects that develop by complete metamorphosis completely change in appearance from young to adult. These nine orders contain the majority of insect species. In fact, they number more than any other species in the entire animal kingdom! This major group includes beetles, moths, butterflies, flies, fleas, ants, bees, and wasps.

Insects with complete metamorphosis hatch from eggs. Once the insect hatches, it is a larva. A few examples of larvae are grubs, maggots and caterpillars. The purpose of the larval stage or cycle is to feed and grow. Larvae continue development through a number of molts until they become mature. The next stage or cycle is the larvae, which molt and then change into pupae. The purpose of
the inactive pupal state is one usually of complete body change. This complete change is when the insect becomes an adult. Reproduction occurs during the adult stage.

Figure 7.3 Development with gradual metamorphosis

Figure 7.4 Development with complete metamorphosis (example: flea). (Provonsha)

Considerations of Pest Management - Stages of insects with complete metamorphosis support rather than compete with each other. It is as if two different needs and habits represent the single species. The larvae feed and live on one habitat and sometimes leave the area to pupate in another. The adult emerges and often eats a different food and lives in a different area. The adult may return to the larval feeding site only to lay eggs. For this reason, pest controllers manage species with complete metamorphosis in different ways. They must manage them according to the different stages, where each lives, and what each does. The reader should pay special attention to the sections that discuss the growth cycle, behavior and harborage of each species.
SECTION 2

STRUCTURE-INFESTING PESTS

The pests discussed in this section are typically ones that infest structures. These pests remain inside structures generation after generation. As long as the necessities of food, moisture, and harborage are accessible in the structure the infestation will continue. Many of these species are multinational or cosmopolitan. These species have been carried over much of the world by human migrations of trade or conquest. A few (cockroaches, for example) have adapted so well to human habitats that their origin cannot be identified. Ants are the possible exception to this grouping. Ants can be considered either structural (Section 2) or invading pests (Section 3). Some species can persist indoors. They live in colonies so they have been included in this section.

Other pests that invade structures include stored product pests, fabric pests, silverfish, firebrats, and fleas. These pests normally lived outside before humans began providing them with a suitable indoor habitat. Habitat alteration is a primary means of controlling these pests.
LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Be able to identify cockroach species by their common names according to their physical characteristics and egg cases
- Know the stages of the cockroach life cycle
- Be able to match each species of cockroach with its habitat
- Know the monitoring and control strategies for each species of cockroach
- Know all elements of cockroach management, including sanitation, proper selection of pesticides, application techniques, and other control methods
- Understand how to use baits effectively to control cockroaches

COCKROACHES

Cockroaches have survived for more than 300 million years. Ancient cockroach fossils have the same look as today’s cockroaches. They are oval and flat with long legs and antennae. The modern cockroach has the same need for a warm, moist climate. Worldwide there are about 3,500 kinds of cockroaches. Most of these live in the tropics. There are a few called urban cockroaches. Urban cockroaches prefer the even temperature and moist conditions that humans have in their homes and workplaces.

Knowing likeness among and differences between species is important. Sharing this knowledge with clients will give them more confidence in your professional ability. The applicator can consider effective control of cockroach habitats. Except for size, all cockroaches are similar in overall shape and looks.

THE GERMAN COCKROACH

(Blattella germanica)

The German cockroach is the most common cockroach infesting structures. It is very successful at doing this. German cockroaches are hard to control. Pest control applicators should double their efforts in analyzing every German cockroach infestation. The German cockroach is considered a pest because it damages food, household items, and because of health issues. They should be prepared to use more than one type of treatment to control the infestation.

Public health - The German cockroach may carry disease-producing organisms like bacteria, protozoans and viruses on their bodies. They also transmit different forms of gastroenteritis to people like food poisoning, dysentery, diarrhea, and other illnesses. The cockroaches carry the vectors causing these diseases on their legs and bodies. Cockroach excrement and cast skins also contain a number of allergens. Many people have allergic responses such as rashes, watery eyes, sneezing, nasal congestion and asthma.

Damage - German cockroaches produce odorous secretions that can affect the flavor of foods. They can also contaminate food with disease-causing organisms. They damage food, which has to be disposed of. This is very costly to the person who owns the food.

Description - German cockroaches are small, about 1/2 inch to 5/8 inch long. They are tan to light brown and have two dark parallel streaks running from the head to the base of the wings. Although it has wings, it is not able to fly.

Nymphs do not look like cockroaches so many people do not think they are cockroaches. They appear quite different from the adults. When they molt they change to an ivory color before they turn back to dark brown. When people see them in this state, they do not recognize them as cockroaches.
Life cycle - Eggs. The egg capsule (apothecia) of the German cockroach is about ¼” long. Half of it sticks out from the female’s abdomen. The female carries the egg capsule this way for about three weeks. Then she drops it about one day before the eggs hatch. The drop usually takes place in a secluded part of the infestation area. To drop the egg capsule much more than one day before hatching time, the young inside will die. Each egg capsule contains 30 to 40 eggs. A female can produce four to eight capsules in her lifetime.

When the female goes into safe hiding, she takes the capsule with her. This reduces exposure to possible harm to her and the egg from pesticides. In extreme danger, she will detach the capsule and flee. The female will abort the capsule in extremely dry atmospheres. Even after elimination of the cockroach population, there are still egg cases that could possibly hatch. It only takes two months for them to become adults and the infestation starts again.

Nymphs. The eggs hatch when the nymphs inside create pressure that splits the case. This allows the young nymphs to get out. They often stay close to the opened egg capsule after hatching. The nymphs molt as they develop. They molt about seven times before reaching adult stage. Nymphs look different from adults because they do not have fully formed wings. These are called instars. The two dark parallel streaks run the length of the thorax.

Adults. Winged adult cockroaches emerge from their last molt. They join a nearby group of other adult and larger nymphs. Aggregation pheromone, a short-range odor, holds the group together.

Habitat and behavior - German cockroaches live in areas of high humidity with food nearby. Cockroaches prefer a shelter where they fit closely. As the number of cockroaches increases, the shelter is over-filled. They will find new sites during their peak foraging periods, which occur just before dawn and after dark.

Aggregations:
- Serve as the natural group where large nymphs and adults of both sexes remain together, thus mating continues
- Are maintained in areas with favorable temperature, humidity, food supply, and protection

Mating. Females do not respond to mating behavior for more than one week after becoming adults. The closeness of space for mating is very important because males and females have to touch antennae. When they touch antennae, they exchange sex pheromones to initiate mating. After mating, females feed intensively for several days. After feeding, they seek a secure hiding place where they can be safe with their egg capsules.

This seclusion means that females with egg capsules feed less. Exposure to pesticides will be less because of the seclusion and less feeding. Preventive pesticide applications are likely to be less toxic by the time female roaches contact them. Clients often report seeing no adult roaches after an applicator’s last treatment but later will observe “babies.” The client is reporting seeing small nymphs that hatched from capsules that were in the shelter. These capsules are from females that were not exposed to the applied pesticide.

Foraging. The foraging pattern of the German cockroach is much less, than you would expect. The cockroaches leave their shelter and usually go to the first perpendicular surface they find. Then they stop, turn and move along the intersection of the two surfaces (usually a floor and a wall). One can imagine food crumbs often wind up in the same places; that is, in wall moldings, corners made by walls, stoves, counters, canisters, etc.

The most convenient shelter, in and around refrigerators, stoves, under sinks, and undisturbed cabinets, provides both protection and food. The most favorable humidity level is found in kitchens with sink traps, leaking faucets, standing water, wet sponges, etc. A bathroom is favorable because of the toilet bowls, sinks, wet washcloths, and sometimes water heaters. Though there is less food in bathrooms, food areas are usually nearby or available through holes around plumbing pipes. These pipes provide additional shelter and areas for population expansion.

German cockroaches are not likely to leave favorable shelter unless population pressure or other negative changes occur. Such “other” changes can be caused by:
- Pest-proofing/Sealing
- Intensive cleaning
- Pesticide applications
- Reduction of temperature or humidity
If cockroaches find new locations with favorable conditions, they can migrate from one shelter to another or develop new infestations.

In areas of high infestation, German cockroaches can build up outside heavily infested apartment units in the summer. Most often, outdoor infestation are found only outside the structures from which a steady migration occur, and near dumpsters and garbage cans (sources of food).

**CONTROL AND MANAGEMENT OF THE GERMAN COCKROACH**

**With Flashlights.** A flashlight inspection is the most intensive method to locate roaches. The applicator can search in dark, undisturbed shelters that a client may have overlooked. Hand mirrors, magnifying lens, or small tools may be helpful.

**With Traps.** Use of sticky traps is common in inspection, detection, and monitoring of roaches. Correct trap placement depends on the applicator’s knowledge of the cockroaches’ foraging habits. For instance, some indicators might tell you size of the infestation but not the location of their shelter.

Once you have identified that German cockroaches are infesting a structure, you need to start your control strategy. Your first choice should be habitat alteration. Applicators should explain to their clients that when changes are made to alter the cockroaches’ habitat, they are affected by them. These recommendations are to:

- Keep food in tightly sealed, pest-resistant containers, such as snap-lid plastic containers and Ziploc bags. Paper and cardboard are not insect-resistant.
- Keep bags of dry pet food in plastic containers with snap-closed lids or big pots such as canning kettles with tight-fitting lids. Pick up pet food between feedings.
- Store leftover food inside a refrigerator with a good seal around the door.
- Keep counters, food preparation surfaces, kitchen appliances, and floors as clean as possible.
- Periodically intensively clean kitchen areas; focus on areas where grease accumulates: exhaust hoods, microwave ovens, stoves, countertops and refrigerators.
- Store food waste in closed plastic trash bags in outdoor trash receptacles.
- Thoroughly rinse out bottles and cans with soapy water before storing for recycling.
- Seal around utility penetrations to reduce cockroach passageways.
- Dehumidify and provide ventilation to dry out moist areas. German roaches survive longer in higher relative humidity.
- Reduce available drinking water. Sources of drinking water are sink traps; drain pipes, washbasins tubs, toilet bowls, condensation on pipes and windows, leaky pipes and faucet, pet dishes, etc.

- Vacuum up cockroaches and egg capsules. The crevice attachment can be used to vacuum cockroaches in cracks. Use HEPA if possible.
- Dispose of the vacuum bag in a sealed plastic bag.
- Caulk and/or paint to seal cracks and eliminate hiding places for cockroaches.
- The crack and crevice pesticide application is preferred. Use a narrow diameter extension tube with a solid stream nozzle. Provide a thorough application of an appropriate residual insecticide or bait into cracks and crevices in furniture, drawers, countertops, sinks, around pipes, and in high cabinets. First, remove utensils, food and supplies from cabinets. Do not treat shelf surfaces.
- In homes, offices, and other non-food areas, use spot applications and apply appropriate pesticides to areas where insects are likely to occur. Apply spot treatments only when they can be safely used in areas of known infestation (application areas, ideally of no more than two sq. ft.).
- **Space treatments** include aerosols, fogs, or ultralow-dosage dispensers. They flush cockroaches out of harbories, causing them to cross residual pesticide, and may kill cockroaches by direct contact. However, these applications lack good crack and crevice penetration. Some populations of German cockroaches are resistant to pyrethroid formulations. Resistant cockroaches will survive to repopulate the account. The need for repeated fogging at short intervals indicates populations are rising, not decreasing. Fog treatments should not be used in food or occupied areas without prior removal of food.
- **Baiting** can be an effective method to control or eliminate cockroaches from a structure. Baits containing hydramethylnon, sulfuramid, boric acid, abamectin, or fipronil should provide a high level of control when applied to those areas where cockroaches harbor. Care should be taken to follow the label instructions for use.
- **Growth regulators** can be an effective method to control or eliminate cockroaches from structures. Growth regulators interfere with the molting process.

**BROWN-BANDED COCKROACH**  
*(Supella longipalpa)*

A brown-banded cockroach has been found in a fossil record of 300 million years ago in Ohio. These bugs have been here a long time. The brown-banded cockroach is considered a pest because of the food it contaminates and health issues. The brown-banded cockroach is not as wide spread as the German cockroach. If they are left untreated, their infestations can build up to rival them.
They prefer to live in warm, rather dry, elevated areas of buildings. The brown-banded cockroach seeks harborage in water coolers, behind wall hangings, behind exit signs, under tables and furniture and closet shelves. They also hide in electrical appliances, office equipment, making control difficult, and allowing transport of infestations when occupants move to new buildings. The male can fly when disturbed.

**Public Health** - Brown-banded cockroaches are known vectors of bacteria and other diseases. Their fecal material, hairs and cuticles are the source of allergies and asthma for many. They also have an unpleasant odor about them.

**Description** - The brown-banded cockroach is a small species about 5/8” long. It is tan to light brown. It has two light-colored bands across the wings and abdomen. The bands sometimes seem to be broken or irregular but are very noticeable. The wings may hide the bands. The male has wings that cover his abdomen and is capable of flight. The females’ wings do not cover the abdomen completely. The male appears slender and the female appears wider.

![Brown-banded cockroach](Image courtesy of University of Nebraska – Entomology)

**Life cycle - Eggs.** The brown-banded cockroach forms an egg capsule. She then carries the capsule for less than two days. She glues the egg capsule to an object in the shelter site. The capsule is very small - only about 1/8 inch wide and 1/4 inch long. It is oval and a light to brown color. The female usually glues the capsules in clumps underneath furniture, behind kitchen cabinet drawers, and in corners inside cabinets, and cabinet frames. These capsules hatch in about 50 days at warmer temperatures. They may take up to 95 days to hatch at room temperature of about 72° F. A female may deposit 10 to 20 egg capsules in her lifetime. The number of nymphs that can hatch from one brown-banded cockroach egg capsule is 14 to 18.

**Nymphs.** Nymphs molt six to eight times in five to nine months at normal room temperatures. At higher temperatures, the nymph period is nearly cut in half.

**Adults.** Adult brown banded-cockroaches live about six months past the nymph stage. Male flight can be seen when lights are turned on during their foraging periods. The females do not fly.

**Habitat and Behavior** - Brown-banded cockroaches, like German cockroaches, build the highest populations in kitchens. Their tendency is to flourish in apartments and homes where high temperatures are maintained. They frequent high cabinets and favor areas near stoves and warm motors, like those in refrigerators, electric clocks, light timers, televisions, and radios.

**CONTROL AND MANAGEMENT OF THE BROWN-BANDED COCKROACH**

Monitoring cockroaches carefully will give you information on population numbers and breeding locations. You can evaluate the success of different control methods. This way you can have the best IPM program.

- Use sticky traps to monitor population levels and to identify breeding locations. Hot melt adhesives (non-volatile glues) are excellent surfaces for capturing cockroaches. The trap surface must be tacky enough to hold these light insects as they scamper onto the glue. There have been many improvements in the design and function of sticky traps in recent years. Place traps high up along walls and near ceilings to detect cockroaches nesting in the warmer areas of a room.
- Baits are a very effective tool in cockroach control. Improvements in bait formulations have dramatically reduced cockroach populations. The active ingredient may vary from bait to bait as well as the food based attractants. Baits are producing remarkable results. In time however, cockroaches may develop resistance to the active ingredients and food matrices used in the baits. Baits in a containerized distribution unit are more expensive and less flexible to use than formulations applied with a bait gun. Baits are less likely to be exposed to the public or contaminated.
- Synthetic juvenile hormones in IGRs prove to be valuable in locations where bait stations cannot be used because of extreme moisture conditions. These hormones interrupt the molting process. They prevent nymphs from reaching adulthood.
- Residual powders and dusts work well in structural voids.
- Clean up clutter wherever it is found, including folded paper bags stored between appliances, items that fall behind drawers and storage in cardboard boxes.

Apply sealant around pipes and other wall penetrations. Where possible, suggest that the client clean and replace shelf paper and drawer liners. Suggest that they reduce
clutter and consistently remove garbage before nightfall. Eating in non-dining areas should be discouraged.

A biological control for brown-banded cockroaches is a small wasp, Comperia merceti that is a parasite on the egg capsule. A female wasp seeks dark areas where she can find brown-banded cockroach egg capsules in which she lays her eggs. The tiny wasp larvae eat the cockroach eggs, and then emerge from the capsules. Then they fly to the windows where the males and females meet and mate. Thus, the cycle begins again. This parasite has been used as part of a cockroach management program.

- Use a narrow-diameter extension tube in infested crack and crevices to provide a thorough application of residual insecticide. The insecticide should be applied under furniture, drawers, countertops, sinks, and into plumbing penetrations and crevices of high cabinets. First, remove utensils and supplies in cabinets. Do not treat shelf surfaces.
- Consider pesticide formulation not readily absorbed by the unpainted wood.
- Bait stations with a long active period are effective but should not be contaminated by sprays or dusts that may be repellent. Place an adequate number in or very near shelter.
- Spot sprays often break down before egg capsules hatch.
- Space sprays lack crack and crevice penetration.

**AMERICAN COCKROACH**

*(Periplaneta americana)*

The American cockroach is a large species of winged cockroach. This cockroach has a lack of cold tolerance. That is why they are commonly found near human habitats. The American cockroach is considered a pest because it invades structures for refuge and food. This cockroach has worldwide distribution because of its travel on ships and its travel throughout the United States. It is sometimes called the Palmetto bug or waterbug.

The American cockroach can move very quickly. It can dart out of sight when someone comes into the room. It is one of the fastest running insects. In an experiment carried out at the University of California at Berkeley, USA, on the American cockroach, a *Periplanta americana* registered a record speed of 3.36 m.p.h. It is a very mobile insect and males of the species can fly.

**Public Health** - The American cockroach may carry disease-producing organisms like bacteria, protozoans and viruses on their bodies. They also transmit different forms of gastroenteritis (like food poisoning, dysentery, diarrhea, and other illnesses) to people. The cockroaches carry the vectors causing these diseases on their legs and bodies. Cockroach excrement and cast skins also contain a number of allergens. Many people have allergic reactions such as rashes, watery eyes, sneezing, nasal congestion and asthma.

**Damage** - American cockroaches produce odorous secretions that can affect the flavor of foods. They can also contaminate food with disease causing organisms. They contaminate food, which has to be disposed of. This is very costly to the person who owns the food.

**Description** - Adult American cockroaches are 1 to 1 ½ inches long. The wings of the male extend slightly beyond its body. The wings of the adult female are shorter. This cockroach is reddish brown and the pronotal shield of its thorax has a light colored ring around it.

**Life cycle - Eggs.** The American cockroach drops her egg capsule in about one or two days after formation. The capsules are about 5/16 inch long and 3/16 inch wide and contain about 16 eggs a piece. Egg capsules that are clean, dark, and dropped in the open are an indication of high populations. Adult cockroaches can live up to one year. Adult females produce about 150 young during her lifetime.

**Nymphs.** Nymphs are gray when they first hatch. After their first molt, they turn reddish brown like the adults. The nymphs molt up to 13 times before reaching adulthood. It can take 6 to 21 months for American cockroach nymphs to mature, depending on temperature. American and Oriental cockroach nymphs are sometimes difficult to tell apart.

**Adults.** Adults commonly live more than one year. Flying American cockroaches are only found in the southern United States.

**Habitat and behavior** - Large populations of American cockroaches live in warm moist habitats. In the summer, they inhabit storm sewers and subpavement gaps. In the winter, they are found indoors. You can find them in boiler rooms, basements, tunnels or other shelter with sources of heat, steam pipes, floor drains, and water sumps.
CONTROL AND MANAGEMENT OF THE AMERICAN COCKROACH

Search areas that provide warmth and high humidity.

- Seal around plumbing and other penetrations in the wall; screen equipment drains and floor drains; keep drain traps full or capped
- Remove firewood stacked in attached garages, porches, patios, etc.
- Replace mulch near doors and window wells with plastic absorptive ground cover and gravel
- Ventilate humid places
- Use pesticide formulations that are not readily absorbed by porous surfaces (concrete floors, bricks, stones, soil, etc.) Apply them in cracks and crevices
- Apply pesticides as outside barriers or spot treatments when they can be safely used in the areas of known infestation
- Use space sprays to quickly reduce large population indoors
- Large bait stations are effective when properly placed in proper quantities
- A sex pheromone and food lures are available to attract males to traps

ORIENTAL COCKROACH (Blatta orientalis)
The Oriental cockroach is also called the “water bug” because they like damp, dark, and cool areas for shelters. They forage mostly on first floors of buildings. Outdoors, during warm months, you can find them under pavement, decomposing leaves or stones, in mulching materials, in trash and at municipal sewer plants.

Public health - The Oriental cockroach may carry disease-producing organisms like bacteria, protozoans and viruses on their bodies. They also transmit different forms of gastroenteritis (like food poisoning, dysentery, diarrhea, and other illnesses) to people. The cockroaches carry the vectors causing these diseases on their legs and bodies. Cockroach excrement and cast skins also contain a number of allergens. Many people have allergic responses such as rashes, watery eyes, sneezing, nasal congestion and asthma.

Damage - Oriental cockroaches feed on all kinds of filth, rubbish, and other decaying organic matter. They seem especially fond of garbage and the contents of discarded tin cans. If water is available, they can live for a month without food. They can only live about two weeks with out water. The most important aspect of cockroach damage derives from their habit of feeding and harboring in damp and unsanitary places such as sewers, garbage disposals, kitchens, bathrooms, and indoor storage areas. Filth from these sources is spread by cockroaches to food supplies, food preparation surfaces, dishes, utensils, and other surfaces. Cockroaches contaminate far more food than they are able to eat.

Description - Adult Oriental cockroaches are about one inch in length. The male and female adults are very dark brown, almost black. They have a greasy sheen to their bodies. Females have non-functional wings and a broader and heavier body. Males have wings that cover 3/4 of their abdomen and they are unable to fly.

Life cycle - Eggs. The Oriental cockroach produces an average of eight egg capsules from spring to midsummer. This cockroach has only one generation per year where temperatures are cool in the winter. They carry their egg capsule for a little more than 24 hours before they place it in a protected spot. Eggs are irregularly shaped, black, 3/8 inch long and 1/4 inch wide. Eggs hatch in about two months. Each capsule contains about 16 eggs.

Nymphs. Nymphs are active from about March through much of the summer. They molt seven to ten times during this period. When they hatch from the eggs, they are a pale brown. After their first molt they become a reddish brown to black. It is very difficult to distinguish nymphs of the Oriental cockroach, American cockroach and Pennsylvania wood cockroach because they look the same.

Adults. In early spring, you find only adult Oriental cockroaches. By late spring, nymphs are abundant. As nymphs increase, adults die off. By August any adults that are found are new adults from nymphs. By fall, almost the whole population is adult.

Habitat and behavior - Oriental cockroaches favor crawl spaces, building foundations, under sidewalks, mulches, water meters, basements and their floor drains, and other moist places. These cockroaches frequently live in floor drains that drain directly outside. The cockroaches use these drains as entrances into homes. The Oriental cockroach prefers starchy food and builds up population around garbage cans. They tolerate lower temperatures than other cockroaches and may winter in rock walls and other protected sites. These cockroaches are more sensitive to lack of water than other cockroaches.
CONTROL AND MANAGEMENT OF THE ORIENTAL COCKROACH

Survey - To control Oriental cockroaches, it is important to do a thorough inspection. A cockroach survey (trapping) is sometimes necessary to determine the extent of an infestation. Even though a thorough inspection will not reveal all cockroach shelters, it may reveal the areas where they forage most actively at night. Surveys are particularly useful in houses and buildings where there is a moderate to heavy level of infestation.

Cockroach surveys involve placing sticky traps at strategic locations within the building. Make sure you place survey traps either against a wall or in a corner of the floor. Most commercially available traps come complete with food lure to encourage cockroaches to enter. One week of trapping at a sufficient number of trapping sites usually provides enough information for more complete and effective control.

Sanitation, Structural Modifications, and Repairs - Modifying the interior environment—removing food, moisture, and harborages for cockroaches—is the first step in treatment. Eliminating cockroach harborages and entry points involves pest-proofing foundations or making similar structural repairs in the kitchen, bathroom, and other areas of the house.

- Seal all penetrations through ground-level walls
- Stop water leaks, screen equipment overflow drains, and take overflow water away from building; keep drain traps full or capped
- Remove rotting leaves from window wells
- Move garbage cans out of preferred moist habitat
- Stop erosion that causes soil voids
- Ventilate moist spaces
- Chemical Control - Dusts such as boric acid, silica aerogel, and diatomaceous earth can be applied to voids and other harborages such as cracks and crevices. Do not apply dusts to wet or damp areas. Dusts should be applied lightly because heavy deposits may repel cockroaches. Do not place dusts where children or pets could be exposed to them. Take care to keep children away from areas treated with boric acid. Take precautions to assure that the dusts do not contaminate food
- Perimeter residual insecticide sprays may aid in the reduction of Oriental cockroaches entering homes from the exterior. Sprays should be applied as to create a continuous barrier around the structure. Use only those materials labeled for this type of application.
- The use of residual sprays or aerosol foggers within a structure is of little value in controlling Oriental cockroaches. In fact, these applications may disperse the cockroaches making control difficult and lengthy
- Baiting can be an effective method to control or eliminate cockroaches from a structure. Baits containing hydramethylnon, boric acid, indoxacarb, imidacloprid, fipronil or abamectin should provide a high level of control when applied to those areas where cockroaches harbor. Care should be taken to follow the label instructions for use.

PENNSYLVANIA WOOD COCKROACH (PARCOBLATTA PENNSYLVANICA)
The Pennsylvania wood cockroach considered occasional pests in homes. This cockroach is not normally a household pest. The Pennsylvania wood roach does enter homes in firewood and through wood shake siding on homes. It is widely distributed throughout the United States.

Public Health - The Pennsylvania wood cockroach does not pose much of a health threat because they are an occasional invader and mostly live outside homes.

Description - Adult males are approximately 1 inch long. The females grow to about 3/4 inch long. Males are dark brown. Their thorax and the front half of the wings are margined with yellow. Adult males are fully winged. Adult females have small short wings that are functionless. Wings of the male are longer than its body. The males fly swiftly but do not have the ability to sustain themselves in the air for long periods.

Life cycle - Egg. Egg capsules are laid during the warm months and deposited behind the loose bark of dead trees, fallen logs, or stumps. Egg capsules are yellowish brown and characteristically curved on both sides like a half moon. Capsules are twice as long as wide, each containing 32 eggs. The egg stage lasts about 34 days at 80°F.

Nymph. Nymphs are usually found outdoors beneath loose bark in woodpiles, stumps, and hollow trees.

Adult. Adults are usually found outdoors beneath loose bark in woodpiles, stumps, and hollow trees. Brought indoors on infested firewood, they wander about the house without congregating in any particular room. They can be especially troublesome during the mating season,
which is during May and June. Male wood cockroaches frequently travel in large numbers and fly considerable distances. They are attracted to lights at night and may gain entry indoors. Large numbers may also be found in rain gutters of homes.

Habitat and behavior - The Pennsylvania wood cockroach feeds primarily on decaying organic matter. Both females and males have been found under shingles and on the inside of garages. They rarely breed indoors. However, with the growing use of firewood, the popularity of cedar shake shingles, wood siding, log homes and the trend of building of homes in wooded areas, problems with the Pennsylvania wood cockroaches will probably escalate.

CONTROL AND MANAGEMENT OF THE WOOD ROACH
Breeding populations rarely become established indoors; house interiors should not be treated. Treat exteriors only when wood cockroaches enter homes from the surrounding environment.
LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Be able to identify key features in the life cycle, habitat, and appearance of the common species of ants
- Be able to distinguish one ant species from another on the basis of their appearance, behavior, and habitat
- Be able to explain the differences between ants and termites
- Know the clues for determining whether ants are nesting inside or outside of a building
- Know which areas to inspect inside and outside of the structure to identify problem ant colonies
- Know what types of habitat alterations and pesticide applications are needed to control ants
- Be able to select the appropriate control and management procedures, both chemical and non-chemical, for each species of ant
- Know how to effectively use baits to control ants

Ants are the predominant or dominant group of social insects related to bees and wasps. They flourish on all areas of the earth except for Polar Regions. All pest control applicators become involved with ant problems sometime in their careers. The most common reasons are foraging or nesting inside structures, or because swarming ant reproductives are confused with swarming termites.

INTRODUCTION TO ANTS

THE ANT COLONY

The winged female reproductive ant mates with a male reproductive either during flight or on the ground. The male dies shortly after mating. The female then digs or adapts a cavity, usually in the soil or decaying wood. She will wall herself into the cavity. If her wings have not broken off by this time, she will tear them off. She then produces eggs. When the tiny, white, legless grubs (larvae) hatch, they feed on salivary secretions from the females’ stored fat cells and useless wing muscles. After several molts, the larvae change into soft, white pupae that look like motionless, white adults. Before they puate, the larvae of some ants (carpenter ants and some other ants) spin a cocoon. When the pupae have made all the internal changes for adult functioning, they molt into the adult stage. Adults take one of three roles of castes of the community: workers (all sterile females), female reproductives (queens), or male reproductives.

- Males live short lives – they mate and die
- Ant queens are females. They mate and raise the first brood by themselves. Afterwards, they produce eggs for the subsequent broods that go on to comprise the colony. They may live many years.
- Workers, also females, tend the eggs, larvae, and pupae. They forage outside for food, enlarge, and defend the colony.
- Other specialized groups may arise from the worker caste in certain species, for example soldiers (ants that defend the colony).

Foraging - Ants eat a wide variety of foods, including other insects, seeds, nectar, meats, greases, sugars, and honeydew. Honeydew is a liquid produced by plant sap-sucking insects of the Order Hemiptera, such as aphids, mealybugs, scale insects, and plant hoppers. These insects feed in groups on plant stems and leaves. Many species of ants protect the insects from other insects and take the honeydew that these small sap-sucking insects produce.

Ants may appear to wander randomly until they locate a desired resource. Then they create distinct trails from the colony to food sources and back. Ants communicate with one another using various behaviors and chemical
messengers (pheromones). Workers foraging for food attract attention and communicate their messages when they return to the colony.

Ant and termite swarmers - The swarming of small, dark insects near or inside a structure often disturb people who fear their homes are infested by termites. Pest control technicians must be able to distinguish between ant and termite reproductives and communicate the differences clearly and confidently to their clients.

Principal differences are:

- **Ants** have complete metamorphosis that is; they go through the egg, larva, pupa, and adult stages each of which looks different from the others. Ant workers are adults.
- **Termites** have gradual metamorphosis. They go through the egg, nymph and adult stages. Nymphs look much like adult workers. Reproductives are dark-bodied.
- **Ants** have a thin or pinched waist (called the pedicel) between their thorax and the gaster. The abdomen is comprised of the pedicel plus the rounded gaster.
- **Termites** waists are NOT narrow. Termite bodies are straight-sided with no constriction. Thorax and abdomen blend together.
- **Ants** have elbowed antennae. A long, straight segment connects to the head. Remaining segments flex and bend.
- **Termites** antennae are entirely flexible. They are made of many small segments strung out like beads. Termites wave them in front using them to touch and feel.
- **Ant reproducitives** have two pairs of wings. The front pair is wider and longer than the back pair. Often ants have a dark spot on the leading vein of the front wings, and you can see the dark wing veins. Ant wings do not break off easily.
- **Termites** wings are long and narrow. Both pairs are the same shape and almost the same length. Termite wings break off with a touch. If termite swarmers have been crawling, their broken wings litter the swarm area. You cannot see termite wing veins with the naked eye.

ANT CONTROL AND MANAGEMENT

It is important to note that, of the ants found indoors, only a few ant species are responsible for the majority of infestations. Some species are not common but appear sometimes. You can find other types of ants inside only under rare or accidental conditions. The later group is difficult to prepare for, but you can study and discuss the major species, and analyze control experiences. Species that appear on occasion take a lot of the applicator’s time with inconclusive results. These elusive ants may appear several times in one year, then not be encountered for several years. Some ants are common in some regions and uncommon in other regions.

The best way to learn about ants is to build a reference collection and keep it for comparison. Elements important to consider when identifying and controlling are:

- **Size** – Each ant species exhibits a consistent size range.
- **Nodes** – Nodes are the raised portion of the small segments that form the waist or pedicel. Most species have one called the petiole while other ant species have two, the petiole plus post-petiole.
- **Color** - Color may vary within the same species of ant, but it can also be a useful eliminating factor. Be sure to note the surface appearance of the exoskeleton.
- **Range** - Most ant species are known to occur in a specific region.

An important first consideration in the control of ants is to determine whether the ant colony is located inside or outside the structure.

Indications that a colony is inside are:

- You find ant workers consistently inside over a long uninterrupted period.
- Observe accumulations of ejected debris on surfaces indoors (such as fragments of wood or insulation, particles of soil and insect body parts).
• You expose a nest during remodeling
• You observe swarming inside building

Indications that a colony is outside are:
• Ants inside can be “tracked” outside.
• Ants outside can be seen coming inside.
• Nesting sites outside are near the infested structure (look for mounds near the foundation, or trees containing carpenter ant colonies on the property).
• Ants nest under slabs or swarm inside, but workers do not forage inside.

Whether the colony is indoors or outdoors, ants that are known to tend honey dew-producing insects often forage inside before plant insect populations can build up outside. After populations of aphids, mealybugs, scale insects, whiteflies, and planthoppers become numerous (in late spring), and colonies nearby put a great deal of energy into tending and protecting these plant sap-sucking insects. Worker ants foraging inside kitchens and basements often leave houses at the same time. They may return in dry weather seeking moisture but often will not be seen until the next spring. When pest control efforts coincide with this period, it is often difficult to tell whether the pest management procedures are effective or whether the ants abandoned the structure for other reasons.

The following general considerations are important in developing an ant control plan:
• Get a sample to properly identify species.
• Talk to the client. Get all information possible from the resident.
• Observe ant worker movement and plot on a diagram. Look for the focus of the infestation.
• To confirm observations, use monitors baited with foods containing protein, grease and sugar (e.g., peanut butter, honey and mint apple jelly).

Inside: Inspect holes and cracks where workers enter, old or new moisture stains, food spills accumulations (e.g., pet food), appliances (e.g., dishwasher and washing machines), under bathtubs and showers, carpet tack strips (for hidden trails), in drawers, and in corresponding areas in adjoining room or rooms above and below.

Outside: Inspect for workers behind vines, shrubs, and other plants near the house. Inspect near expansion joints, slabs, patio blocks, bricks, boards, and plant pots. Inspect outside door and window frames, in window wells. Check at places where electric and telephone wires, and air-conditioning refrigerant pipes penetrate house walls. Check trees that provide access to houses by overhanging limbs that touch exterior sheathing, gutters or shingles. Inspect and check water meters. Inspect plants for ants tending aphids, mealy bugs, etc.

• Once you have determined where the infestation is located use habitat modification to block ant entry points and make the environment unfavorable.
• Caulk wall penetrations and mortar masonry cracks. Wall penetrations include utility lines, air conditioning lines, phone lines, etc.
• Seal or replace door and window frames.
• Repair water leaks.
• Remove food sources by regular cleaning of counters, floors, appliances and removing pet food, etc. and keeping food in sealed containers.
• Trim shrubbery away from house.
• Remove firewood stacked close to house, also decaying landscaping timbers and debris piles that encourage nesting.
• Seal openings in hollow pillars, columns, and vent penetrations.

Consider the species when choosing baits. Use baits with slow-acting toxins. Baits are excellent in sensitive areas (e.g., computer or hospital rooms) when pesticide sprays are not appropriate. Do not spray or dust around baits. Never store baits or bait material where they can be contaminated with any repellant odors like pesticide fumes.

Ants and other insects can detect minute amounts of repellent chemicals.
• Use crack and crevice treatments in areas where you suspect nests to be. Use dusts in wall voids. Use canned-pressurized liquid pesticides with small-diameter crack and crevice device. You can obtain tubing in different lengths that can be threaded through construction elements to treat areas a good distance from the can.
• Control ant-tended aphids and mealybugs with horticultural pesticides, such as oils or soaps.
• Apply wettable powder or microencapsulated spray formulation where pesticides may be absorbed into surfaces.
• Drill holes where practical to treat into infested structural voids.
• Use spot treatments when necessary, but be wary of repellant activity.
• Use residual granules or drenches with registered formulations to treat ground nests outside.

Develop a specific pest management plan. Where large outside areas need treatment, do not treat as an extension of a yard problem. Consider spot treatments and perimeter spraying carefully. Drawbacks to these reactive treatments include:
• Nest areas can be completely missed.
• Ants may move to other areas of activity.

FIELD ANTS (Formica spp.)
Description - Field ants are medium-size to large ants, (1/5-1/4 inch) often confused with carpenter ants. Field
ants are monomorphic meaning they maintain the same form through growth. They have a wide variation in color: black, brown, tan, reddish, or red and black in color. Their thorax has a double-humped profile. Another key distinguishing feature is the presence of three ocelli on head (ocelli are simple eyes on the top of the head between the ant's compound eyes).

The common name of field ant probably comes from their abundance in turf and soil. This is the largest genus of ants in America north of Mexico, containing about one-sixth of our entire ant fauna. They are also called thatching ants because of their habit of constructing a mound out of excavated soil and thatch fragments. They are found throughout the United States.

Field ant workers measure about 1/4 inch long and may be brown, black, reddish or a combination of these colors. The thorax profile is not evenly rounded on the upper side. There is a distinct notch halfway along the top surface of the thorax. The waist (pedicel) of the abdomen is 1-segmented (single node). Although no stinger is present, these ants will bite and spray pungent-smelling formic acid onto the persons or animals provoking them.

Figure 9.3 Field Ant (Image courtesy of Van Water and Rogers)

CONTROL AND MANAGEMENT OF THE FIELD ANT

One should quickly clean up food and beverage spills from floors, porches and decks (including pet food) to discourage foraging by these ants indoors and near residences and buildings. Field ants that occasionally enter buildings can be removed with a vacuum cleaner fitted with a hose attachment.

Trees infested with honeydew-producing insects can be made less attractive to foraging ants by periodically spraying the trunks with a 1 or 2% detergent solution in a 2 to 3 foot high band pattern at the base. Lawns infested with field ants show signs of damage.

Figure 9.4 Field Ant damage to lawn (Image courtesy of Gerry Wegner, Varment Guard)

Management includes treating colonies by drenching mounds thoroughly with a sufficient amount (1-2 gallons) of an appropriately labeled insecticide using low pressure to insure complete saturation throughout the colony, which may be 8-12 inches or more in diameter. It may be necessary to lift objects on the ground to treat the colony underneath. The colony may also be controlled with granular insecticide bait products.

ODOROUS HOUSE ANT
*(Tapinoma sessile)*

Description - The odorous house ant ranges in color from brown to black and ranges in length from 1/16 to 1/8 inches. Their antennae have 12 segments and are not terminated with a club. It is one of the more difficult ants to control.

Life cycle – This species is a scavenger/predator ant that will eat most household foods, especially those that contain sugar. It will also eat other insects. Indoors they will colonize near heat sources or in insulation. In hot and dry situations, nests have been found in house plants and even in the lids of toilets. Outdoors they tend to colonize under rocks and exposed soil. They can trail extensive distances, usually along landscape edges. Colonies range in size from 100-10,000, and house several queens. They are non-aggressive. Queens lay one egg per day. Typical time to adult phase of development is 34-38 days.

The workers forage along trails. Outside they actively tend honeydew-producing insects and take flower nectar. Indoors, workers seem to prefer sweets.

The common names “odorous house ant” and “rotten coconut ant” come from the odor the ants produce when crushed, which is very similar to the pungent odor of decaying coconut husk.
CONTROL AND MANAGEMENT OF THE ODOROUS HOUSE ANT

- Begin by investigating location where any activity is observed.
- Pyrethrins will alarm these ants, causing them to rush around erratically, excitedly elevating their abdomens. This could cause the colony to fragment and relocate.
- Always inspect outside close to the location of inside activity. Look under stones and boards for colony openings and activity.
- Remove or treat beneath stones, pavers, and landscaping timbers harboring odorous house ant colonies. Remove debris piles.
- Use dusts or residual sprays applied in cracks and crevices in the area of entering worker trails. Ants exhibiting strong affinities to the outside environment (honeydew insects, flower nectar) and with nesting mobility (shallow nests, cavity nests, utilization of protective objects) should be sought outside as well as inside, unless a nest’s locality inside precludes its members from reaching the outside.
- Control populations of honeydew-producing insects on plants near the structure.
- Use pesticides registered for the insects on plants. To maintain parasites and predators of these plant insects, use low-toxicity pesticides such as insecticidal soaps and oils.
- Certain baits attractive to odorous house ants can be used.

PAVEMENT ANT 
(Tetramorium caespitum)

Description – This ant is found in cities in the Midwest. The pavement ant is a common household pest. Its name comes from the fact that colonies usually are located in soil beneath pavement. Two spines on the back, two nodes on the pedicle and grooves on the head and thorax distinguish them.

Life cycle – Pavement ants nest outside under rocks, at the edge of pavement, door stoops and patios. They commonly move their colonies inside between the foundation and the sill plate. Outside, pavement ants tend honeydew-producing insects and feed on other insects and seeds.

During early spring, colonies attempt to conquer new areas and often attack nearby enemy colonies. These result in huge sidewalk battles, sometimes leaving thousands of ants dead. Because of their aggressive nature, they often invade and colonize seemingly impenetrable areas. In the summer time, ants dig out the sand in between the pavements to vent the nests.

Pavement ants get their name because they often nest under sidewalks, driveways and building foundations. During the winter, pavement ants may nest inside structures (i.e., insulated walls by sills) near a heat source.

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Pavement ants are trailing ants and feed on a wide variety of foods including dead insects, greasy foods, seeds and sweets.

Pavement ants store debris in certain areas of the colony or nest. When this area is needed for nest expansion, workers clean out the junk accumulation and dump it. Colonies located on foundation walls eject debris onto floors by baseboards or drop debris from sill plates creating a pile on the basement floor. The ant dump consists of sand, seed coats, dead insect parts, and sawdust from the house construction. Not knowing the frass source, householders often view these dumps with alarm, suspecting they may have carpenter ants or termites.

CONTROL AND MANAGEMENT OF THE PAVEMENT ANT

- Inspect along sill plates in basements, and around heat ducts and baseboards in areas where ant workers are active.
- Look for foraging in the kitchen; such activity may indicate a nest in the basement below or just outside.
- Outside, look for tiny mounds next to the house near windows and doors or nest openings under stones and pavers.
- Treat around or under stones that are sheltering ants.
- Recommend indoor sanitation, including the removal of crumbs, beverage spills and the elimination of moist garbage in dry weather.
- Caulk observed ant entrance points.

**Inside:**
- Apply dusts or sprays in cracks and crevices of baseboard molding where activity is noticed.
- Treat cabinet cracks around kitchen sinks.

**Basement:**
- Treat cracks along foundation walls, under sill plates, and near heat ducts.
- Be careful not to contaminate heat or air-conditioning ducts.
- Treat cracks in slabs on grade foundations as well as the bases of outside doorjambs.
- Baits and granulars can be used to control ants.

**Outside:**
- Treat nests using a drench of water-based residual insecticide applied under low pressure or using pressurized aerosols to penetrate nest galleries.
- Granular, gel, and containerized baits are effective control measures
- Treat cracks and entry points.

**PHARAOH ANT (Monomorium pharaonis)**

**Description** – The pharaoh ant, not much longer than 1/18 inch long, has two nodes. Its head and thorax are dull yellowish to light orange or reddish. It has a shiny dark abdomen, especially at the end.

**Life cycle** - This ant is in most urbanized settings in the United States. Pharaoh ants prefer warmer buildings and warm areas (80° to 85° F) in buildings for nesting. These ants are active year round in houses and portions of large buildings such as hospitals, office buildings, apartment buildings, laboratory buildings, etc. Nesting sites include wall voids, cracks in woodwork, stacks of paper, envelopes, bed linens, bandage packs, desk drawers, etc. It is common to find many colonies in one building and, perhaps, several in one room. Colonies have multiple queens and increase by dividing/budding—one portion of the colony goes with each queen. No swarms have been recorded, so new infestations are apparently transferred by moving infested objects.

Pharaoh ants form conspicuous trails and are attracted to grease, meats, insects, and sweets. Their harborage and food preferences bring it to coffee areas, kitchens, paper and other supply storage, office equipment, medical storage, laboratory benches, many kinds of biological cultures including insect-rearing chambers, and hospital rooms with wound or burn patients—these ants have turned up in IV tubes, medicine droppers, and bandage stacks.

**CONTROL AND MANAGEMENT OF THE PHARAOH ANT INSPECTION**
- Inspect where sanitation is suspect or where food is available, particularly sugars—where coffee is made, where lunches are eaten, in desks where snacks are stored.
- Inspect storage rooms, laboratory media, culture and formula preparation rooms, nurses’ stations, unwashed cups, vending machines, and kitchens frequented by children.
- Prepare pharaoh ant food monitors using small pieces of masking tape or wax paper topped with a little peanut butter, mint apply jelly or honey to demonstrate where ants are most prevalent. Pharaoh ants are easily baited.
- Look at water sites. These ants are attracted to dripping faucets. They drown in plant water bottles and coffee water held overnight. Floating ants are frequently the first sign that these ants are present.
- Reduce stored supplies, where possible.
- Clean, rearrange, and rotate supplies to expose nests.
- Clean food areas before the end of the workday or bedtime and empty water containers that stand overnight.
- Several baits are available for Pharaoh ant control. Place a bait station wherever a trail or a positive response to a monitor trap was observed.
- Place baits where young children and pets will not have access to them.
- Only food-based or non-repellent insecticides should be used for the control of pharaoh ants.

![Pharaoh Ant (Figure courtesy of Van Waters and Rogers)](image-url)
LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Identify common stored-product and fabric pests
- Identify factors that contribute to pest infestation in stored products and fabrics
- List the key features in the life cycles and habitats of common stored-product and fabric pests
- Discuss monitoring and survey techniques for stored-product and fabric pests, including pheromone use
- Discuss inspection and prevention techniques for stored-product and fabric pests

Stored-product pests and fabric pests, for the most part, are beetles (including weevils), and moths. Some of the beetles that are stored-product pests are in the same family (Dermestidae) as fabric-pest beetles. These insects can be destructive pests in homes, warehouses, and mills. In all cases, a thorough inspection and alteration of habitat is the best defense.

STORED-PRODUCT PEST AND FABRIC PEST

Stored products can be infested at every point from their origin to final use in:

- The field where the product is grown, picked, or harvested
- Storage bins or granaries where it is held until sale
- Mills where it is ground, mixed, or packaged
- Warehouses where it is held for use or redistribution
- Food-processing plants where it is added to other products (e.g., candy, pet, food, baking mixes)
- Food-serving establishments where it is prepared for public consumption
- Retail food stores where it is sold
- In pantries and cupboards where it is held for use

PESTS OF WHOLE GRAINS

Few species can chew through the strong seed coat or place eggs inside intact grains. Pests that are referred to as internal feeders include the rice weevil, granary weevil, and the Angoumois grain moth.

RICE WEEVIL
(Sitophilus oryzae)

Figure 10.1 Rice weevil (Image courtesy of Clemson University – USDA Slide Series, Bugwood.org)

Description - The rice weevil is a small snout beetle that ranges 1/6 to 1/5 inch long. The color is dull red-brown to black. The rice weevil has fully developed wings beneath its wing covers and can readily fly. The thorax is densely pitted with irregularly spaced punctures except for a smooth narrow strip extending down the middle of the back. The larval stage of this insect is a soft, white, legless, fleshy grub, which feeds on the interior of the grain kernel. When mature, the grub changes to a naked white pupa and later emerges as an adult beetle.

Life cycle - Adult rice weevils live for four to five months and each female lays 300 to 400 eggs during this period. The female uses her strong mandibles to chew a hole in the grain kernel where she deposits a single egg and seals the hole with a gelatinous fluid. During hot weather, the
development period for egg to adult may be as few as twenty-six days. This period is greatly prolonged during cool or cold weather. Rice weevils are capable of flight, and infestations may develop in the field prior to harvest.

**ANGOUMOIS GRAIN MOTH (Sitotroga cerealella)**

![Image of Angoumois grain moth](Image courtesy of Clemson University USDS Cooperative Extension Slide Series Bugwood.org)

**Description** - The adult Angoumois grain moth is a small buff to yellowish-brown moth about 1/3 inch long. The wingspan is about 1/2 inch long. The front wing is a lighter color than the hind wing. Both wings end in a thumb-like projection and have fringed rear margins. The eggs are white when first deposited but soon turn red. Full-grown larvae are 1/3 inch long and white with a yellow head. The area near the head is slightly larger in diameter than the posterior portion of the insect.

**Life cycle** - Female moths deposit eggs on grain kernels. Under normal conditions, a female will lay forty eggs. The eggs are glued to the kernel. The larvae emerging from the eggs eat through the kernel and begin feeding on the outer shell. Once they are through the outer shell they feed inside the kernel until they mature. The larvae eat a channel to the outside of the seed. Then larvae spin silken cocoons and pupate within the kernels. Adults emerge from the weakened kernels. The life cycle is complete in about five weeks at optimal temperatures.

**PESTS OF PROCESSED GRAINS AND DRY FOODS**

Several species of beetles and moths feed as larvae on the exposed surfaces of cereals and other dry foods. These external feeders are represented by the insects described in this section.

**INDIAN MEAL MOTH (Plodia interpunctella)**

![Image of Indian meal moth](Image courtesy of University of Nebraska Department of Entomology)

**Description** - The Indian meal moth is a moth with a wing expanse of 3/4 inch. It is easy to distinguish from other grain pests by the peculiar markings of the forewings. The wings are bronze with a copper luster on the outer two-thirds and whitish gray on the inner third where attached to the body. The hind wings lack distinctive markings and are uniformly gray. Adults can be seen resting on the grain surface or grain bin walls. The adults fly at night and are attracted to lights.

**Life cycle** - The eggs of the Indian meal moth are whitish, ovate and very small. Because of their small size, they are difficult to see without the aid of a microscope. Eggs are deposited on the grain or dry food surface singularly or in groups of twelve to thirty. Newly hatched larvae are very small and difficult to see. Larger larvae are usually yellowish, greenish, or pinkish. Fully-grown larvae are 1/2 to 5/8 inch in length with a brownish head capsule. Larvae have three sets of legs near the head (thoracic legs) and five sets of pro-legs on the abdomen. Larvae of the meal moth spin a web as they become fully-grown and leave behind silken threads wherever they crawl. The webbing is often sufficiently abundant to attract attention. Loosely clinging webbing on the grain is characteristic of this pest.

A mature female lays 100 to 300 eggs on food material, either singularly or in groups of twelve to thirty. Larvae begin to hatch in two to fourteen days depending on environmental conditions. Newly hatched larvae feed on fine materials and are small enough to pass through a sixty-mesh screen. For this reason, it is difficult to exclude larvae from most packaged foods and grain.
Larvae cannot chew through thick packaging so they must enter through a hole or at the seam. The larval stage lasts from two weeks to one year and is responsible for grain losses. The larval feeding in grain is usually restricted to the top one to two inches. Large larvae feed on the grain germ. When mature, larvae spin a silken cocoon and turn into light-brown pupae. The cocoons and pupae can be seen on the grain surface and walls of the grain bins. Adults emerge in four to thirty days, mate, and females lay the next generation of eggs. Adults live from five to twenty-five days.

SAWTOOTHED GRAIN BEETLE
(Orzyzaphilus surinamensis)

Description - The sawtoothed grain beetle is a widely distributed species. Notice the saw-like edges on its thorax (in the picture). The sawtoothed grain beetle is commonly found in stored grain, rice and packaged dry foods. It is often confused with the less common merchant grain beetle. The sawtoothed grain beetle can be found coexisting with other insects in contaminated grain.

Life cycle - An adult lives an average of six to ten months, but can live as long as three years. The adult sawtoothed grain beetle cannot fly. The females lay between 43 and 285 eggs during their lifetime. Eggs are dropped loosely among grain kernels or tucked into a crevice in a kernel. The tiny eggs are slender and white. The eggs hatch in three to five days when environmental conditions are optimal (80° to 85° F).

The larvae emerge and crawl freely about the grain to feed on broken kernels. Larger larvae may tunnel into kernels to feed. Larvae mature in about two weeks and construct cocoon-like coverings by joining small grains or pieces of grain. Within these structures, the larvae pupate. The pupal stage lasts about a week. Total development from egg to adult requires about three to four weeks.

Although broken kernels are the preferred food, they will feed on sound kernels. This may reduce the dry weight of grain, but total weight may increase because of water absorption caused by the insect. Mold may begin to grow on the grain, which reduces the quality and value. The terminal rejects the grain sometimes because of the quality.

CONTROL AND MANAGEMENT OF STORED-PRODUCT PESTS

Inspection - In large facilities, a pest control technician will want to become familiar with the entire operation before making an inspection. The pathway a product takes is vitally important to detection. Pests can occur in machinery, stacked products, waste dumps, delivery spills, etc. In homes and retail businesses, excess clutter, bad lighting, storage areas with blocked access, and rooms located above or below infested materials are special target sites.

- You should use a strong flashlight when conducting all inspections. A knife, a good hand lens, screwdrivers, and mechanic’s mirrors are also useful equipment.
- Flushing agents can be used, but care must be taken not to contaminate foodstuffs.
- You should give special attention to all spills. Check for pests, cast skins, and tracks in spilled products or dusts.
- Inspect the backs of pantry shelves, floors under shelves, and all dark areas.
- You should use pheromone traps, available for nearly all stored-product pests, where routine inspections are made.
- Keep detailed inspection records. Written inspection findings and recommendations for changes by management or maintenance must be clear.
- Be safe. In commercial accounts use bump hats and be careful of mechanical and electrical hazards.
- Institute a regular and thorough cleaning program. Pesticide use without routine cleaning will not control store-product pest infestations.
- Seal cracks (especially wall penetrations) that connect with other rooms.
- Screen out birds and rodents.
- Recommend good lighting.
- Stop and repair moisture problems that attract insects.
- Point out areas that need ventilation to reduce moisture.
Recommend reduction of clutter and excess product in cabinets or storage.
Collect and discard old rodent bait, which can act as a food source.
Maintain alleys or inspection paths between stacks of products and between products and walls. Have them painted a light color.
Install air curtains at doors to keep out flying insects.
Recommend rotating stock - first in, first out.
Recommend storing materials that are not commonly infested (e.g., animal bedding, paper products, canned foods) away from products that can be infested. Discard infested materials. Where infested products are stored, sanitation is the primary method of population reduction.
You should carefully apply pesticides registered for use in cracks and crevices of the infested area.
Apply spot treatment only in areas where there is an obvious and immediate need to kill migrating insects.
Install insect light traps strategically indoors to attract, capture or electrocute flying insects in commercial accounts.
Investigate pheromone trapping for monitoring in conjunction with other methods.
In homes open and inspect all boxes of products to check integrity of inside packaging.

CIGARETTE BEETLE
(*Lasidomera serricorne* (F.))

**Description** - Adult cigarette beetles are yellowish- to reddish-brown, oval-shaped, and about 1/10-inch long. The head is bent downward sharply, nearly at right angles to the body, giving a humpbacked appearance when viewed from the side. The wing covers (elytra) are smooth, and the antennal segments are uniform and saw-like (serrate).

**Life Cycle** - Female cigarette beetles lay about 30 eggs in a period of 3 weeks. Eggs hatch in 6 to 10 days. The larval stage lasts from 5 to 10 weeks with larvae shunning light. The pupal and prepupal periods last 2 to 3 weeks and are passed in a cell. The life cycle lasts from 70 to 90 days, and there may be 5 to 6 overlapping generations per year in warm localities with only one generation in the more temperate regions. Adults are strong flyers and active in subdued light at temperatures above 65 degrees F. Adult beetles may live from 23 to 28 days. In temperate climates, beetles begin swarming in May and again in August. Overwintering may be passed in the larval stage, with some adults not too resistant to cold hibernating in crevices. In warehouses, the life cycle may be completed in 52 days.

Cigarette beetles commonly infest dried tobacco and tobacco products - hence their name. They also infest raisins, figs, dates, ginger, pepper, nutmeg, chili powder, curry powder, cayenne pepper, paprika, yeast, drugs, legume seeds, barley, cornmeal, flour, soybean meal, sunflower meal, wheat, wheat bran, rice meal, beans, cereals, fishmeal, peanuts, dry yeast, dried flowers, leather, woolen cloth, and bamboo. They also may damage the leaves and bindings of books when feeding on the paste, or overstuffed furniture when infesting the straw, hair, etc.

DRUGSTORE BEETLE
(*Stegobium paniceum* (L.))

**Description** - Adult drugstore beetles are reddish-brown, more elongated, and about 1/10-inch long. The head is deflexed, but does not result in a distinct humpbacked appearance. The wing covers have faint lines running lengthwise (striated), and the antennae have three enlarged segments at the tip.

**Life Cycle** - Female drugstore beetles lay eggs singly in foodstuffs. The larval period ranges from 4 to 5 months, with the pupal stage lasting from 12 to 18 days. The complete life cycle requires 7 months. Larvae form a little
round ball or cell which becomes its cocoon, and in which it pupates. Some have succeeded in rearing the beetle from egg to larvae in 2 months, with 4 broods per year in warm summer months. In cool climates, there is one generation per year.

True to their name, drugstore beetles feed on many drugs in the pharmacy, such as laxative teas and even strychnine. They also infest almonds, peanuts, paprika, red pepper, alfalfa meal, cornmeal, flour, milo, wheat, wheat bran, wheat germ, dry dog and cat food, bread, birdseed, beans, coffee beans, fish meal, spaghetti, instant chocolate, powdered milk, books, manuscripts, dried flowers, certain fillers and fabric coverings of furniture, leather, museum specimens, and other foodstuffs.

**RED FLOUR BEETLE**  
*Tribolium castaneum*

**Description** - Both the confused and red flour beetles are similar in appearance. The beetles measure about 1/8 inch long and are flat, shiny, reddish-brown, and elongated. Antenna segments of the confused flour beetle increase in size gradually from the base to the tip. The segments at the tip of the antennae of the red flour beetle are abruptly larger than the preceding ones, forming a three-segmented club. The eggs, larvae, and pupae are similar in both beetles. Eggs are whitish or colorless and microscopic in size. Food particles stick to the surface of the eggs. Brown-headed larvae are cream to yellow, slender, and wiry, reaching a length of 1/4 inch. Larvae have six legs and two-pointed or forked projections on the rear body segment. Pupae are white to light brown.

**Life cycle** - Female beetles each lay 300 to 400 eggs in flour or other foods during a period of five to eight months. The eggs hatch in 5 to 12 days. The eggs hatch into slender, cylindrical larvae that are cream-colored, tinged with yellow. The length of the larval period ranges from 22 to 100 days and the pupal period is about 8 days. Fully-grown larvae transform to naked pupae, and in about a week adults emerge. The life cycle requires 7 to 12 weeks. Adult beetles live 3 years or more.

Adult beetles are very active, quickly running for cover when disturbed, and are found on the surface or deep in the food material. They can invade poorly sealed storage containers because of their small size and shape. Both beetles breed in damaged grain, grain dust, high-moisture wheat kernels, flour, etc. Both species have been found in barley, breakfast cereals, corn meal, crackers, flour millet, oats, rice, rye, wheat and wheat bran, nutmeats, dried fruits, legume seeds, beans, milk chocolate, cottonseed, peas, powdered mils, sunflower seed, vetch seeds, spices, herbarium and museum specimens and even baits poisoned with arsenicals. The red flour beetle can fly short distances, but the confused flour beetle does not fly.

**CONTROL AND MANAGEMENT OF FLOUR BEETLES**

- Inspect processed flour products and discard those that are infested
- Recommend a sanitation and cleaning program for mills
Recommend that stored products be rotated and/or bought in smaller quantities. Older packages should be discarded if not used as planned.

Retail food stores and warehouses should have on-going monitoring programs.

**PSOCIDS (PSOCOPTERA: TROGIIDAE AND LIPSCELIDAE)**
(*Lepinotus and Liposcelis* spp.)

**Description** - Psocids are tiny, pale gray or yellowish white, soft-bodied insects. Some species have winged adults while others are wingless. They are about 1/16 inch long. Psocids feed primarily on mold that grows on decomposing starchy materials. Psocids are sometimes called “book lice” because they are found in numbers on books and papers sized with starch and stored in damp situations. Psocids require a minimal relative humidity of at least 60 percent. High humidity accomplishes two purposes. It keeps the Psocids from drying out and it promotes the mold or fungal growth on which Psocids feed. High humidity is maintained in poorly ventilated rooms, closets, basements, cabinets and pantries with a moisture source. To eliminate Psocids, discard the starchy source of mold and dry out the storage area using improved ventilation and dehumidifiers or air conditioning.

**Life cycle** - Psocids are all females and development occurs from unfertilized eggs (parthenogenesis). Parthenogenesis is growth of an organism from an unfertilized gamete, or sex cell. It is common in the animal kingdom up through the class Insecta, but it occurs rarely thereafter. Female Psocids deposit an average of 60 eggs that are white, oval, and covered with a crusty coating. The female lays eggs singly or in clusters near a food source where young nymphs hatch and feed on molds and mildews. There are four to six nymph stages with the immature resembling the adults in form and structure. The life cycle, from egg to adult, takes four weeks to two months or more depending on conditions. There may be seven to eight generations per year with adults dying in cold weather and eggs hatching the following spring. Psocids avoid light and prefer temperatures of 75° to 85° F with relative humidity of 75 to 90 percent. Long periods of humid weather, accompanied by warmth, favor outbreaks of Psocids.

These insects feed on microscopic molds, fungi, dead insect fragments, pollen, and other starchy foods in humid environments such as houses, warehouses, libraries, and structures where green lumber is stored or used. Sweating and high humidity may form in wall voids when new lumber becomes enclosed, encouraging Psocids outbreaks. Damp basements, crawlspaces, leaky and sweating plumbing, potted house-plants, cereal, flour, bird nests, furniture stuffing, of natural plant fiber, paste on book bindings, grains, wallpaper, etc. may harbor Psocids.

**CONTROL AND MANAGEMENT OF PSOCIDS**
Use dehumidifiers with good ventilation. Repair leaks, or increase ventilation to reduce humidity.

**CARPET BEETLES**

**BLACK CARPET BEETLE**
(*Attagenus unicolor* spp.)

**VARIED CARPET BEETLE**
(*Anthrenus verbasci* (Linnaeus))

**Description** - Carpet beetles feed on dry animal and plant substances such as wool, fur, feathers, hair, hides, horns, silk, velvet, felts, bone, seeds, grain cereals, cake mixes, red pepper, rye meal and flour. Other substances include...
powdered milk, dog and cat food, leather, book binding, dead insects, bird and rodent nests, and even cotton, linen, rayon and jute, especially when stained with spilled food and animal excreta. The larvae cause the damage, crawling from room to room and living behind baseboards and moldings, and in heating system air ducts, dresser drawers, carpets, clothing and furniture. Feeding damage often occurs under heavy furniture or pianos and at carpet edges. Adult beetles fly readily in May and June. They are attracted to lights at night, and may enter through an open window or door. Some may be brought in accidentally on cut flowers or in furniture that has been in storage or sent out for repair.

**Life cycle** - Adult black carpet beetles are oval and shiny-black with brownish legs. They vary in body length from 1/8 to 3/16 inch. Larvae frequently stay hidden when feeding. The larvae are golden to dark brown and about 1/2 inch long. The body resembles an elongated carrot or cigar with a long brush of bristles at the tail end. Adult varied carpet beetles are about 1/10 to 1/8 inch long and are nearly round. The top body surface is usually gray with a mixture of white, brown and yellow scales and irregular black cross bands. The bottom surface has long, gray-yellow scales. (These scales are 2-1/2 to 4 times as long as they are broad.) Larvae are about 1/4 inch and light to dark brown. The body is wider and broader at the rear than the front. Adult common carpet beetles are about 1/10 to 1/8 inch long, nearly round, and gray to black. They have minute, whitish scales and a band of orange-red scales down the middle of the back and around the eyes. Larvae, frequently moving rapidly, are elongated, oval, reddish-brown, about 1/4 inch long. They are covered with many brownish-black hairs.

All carpet beetles pass through the egg, larva, pupa and adult stages. Adults fly during warm, sunny days and feed outdoor on flower pollen of spirea, dogwood, crepe myrtle and buckwheat flowers. Others feed on daisies, wild asters, etc. Adults are attracted by light, fly into homes and may be found on windows and screens. According to the species, each female might lay 40 to 114 white eggs. The eggs hatch in 8 to 15 days in warm weather. Eggs laid indoors occur in lint accumulations near the food source, in air ducts, under furniture, along and underneath baseboards, etc. After hatching, larvae begin their destructive feeding, avoiding light, and molting several times, as they develop. Sixty days to a year or more may be spent in the larval stage feeding, depending on food and temperature. New adults emerge from the pupal stage of the beetle in the spring. Some life cycles are two to three years depending on the species of beetle. Usually there is only one generation per year for the black and the varied carpet beetle.

**CONTROL AND MANAGEMENT OF CARPET BEETLES**

- Discard or clean any wool or fur product that has not been cleaned since wearing.
- Move furniture and clean wool carpets in infested rooms. Insist on thorough vacuuming of all rooms that can support small beetle populations
- Separate clothes into uninfested, cleaned woolens, or stained and dirty articles that need to be dry-cleaned. Dry-cleaning kills all stages of the beetle and cleaned woolen fabrics retard the growth of the beetle larvae. There is a greater likelihood that furs or woolens in long-term home storage will be infested over those that are used seasonally
- Vacuum along baseboards, underneath refrigerators, stoves, under seat cushions and any other locations where lint can accumulate.
- Store all cleaned fur, feather, and woolen products in tight garment boxes or sealed plastic garment bags. Furs are best kept safely in refrigerated vaults at furriers
- Where infestations are found, spot application of registered pesticides can be applied to structural crevices in storerooms or closets.
- Use naphthalene flakes in tight chests where occupants will not breathe vapors. Naphthalene is not as volatile as paradichlorobenzene (PDB) crystals and gives longer protection. Use only amounts recommended on the label. These two chemicals are sold in department stores as mothballs or moth crystals.

**CLOTHES MOTHES**

Clothes moth larvae feed on wool, feathers, fur, hair, leather, lint, dust, paper, and occasionally cotton, linen, silk, and synthetic fibers. They are very damaging to fabric stained with beverages, urine, oil from hair, and sweat. Most damage is done to articles left undisturbed for a long time, such as old military uniforms and blankets, wool upholstery, feathered hats, antique dolls and toys, natural bristle brushes, weavings, wall hangings, oriental rugs, piano felts, old furs and especially wool carpets under heavy furniture and clothing in storage.

Adult webbing clothes moths have a wingspread of about 1/2 inch. The body is about 1/4 inch long with wings...
folded and golden yellow with a satiny sheen. A tuft of hairs on the head is upright and reddish-gold. Larvae are a shiny, creamy white with a brown head, and up to 1/2 inch long. The larvae spin long threads and construct tunnels of silk.

Adult case-making clothes moths have a 1/2 inch wing spread. Forewings are yellowish-brown, and there are usually three distinct, dark dots on each forewing. Hind wings are smaller, lighter, and fringed with hair-like scales. Eggs are whitish, and larvae are opaque-white with brown heads. The larva spins a small silken case around itself and carries it while feeding.

Clothes moths rarely fly to lights at night and instead prefer darkness, such as a closet or storage chest. Any clothes moths fluttering around the house are probably males, because females travel by running, hopping, or trying to hide in the folds of clothing. Female webbing clothes moths lay 40 to 50 eggs that hatch in 4 to 21 days. Larvae like to feed on soiled material, spinning silken mats or tunnels and incorporating textile fragments and bits of fecal pellets. Larvae will wander some distance away from their food source to pupate in crevices. The pupa case is silken with bits of fiber and excrement attached to the outside. The life cycle is about 65 to 90 days.

The case-making clothes moth is less common than the webbing clothes moth. Larvae spin a small silken case around themselves as they feed. The cigar-shaped case enlarges as the larva grows. When crawling, the larva’s head, thorax, and three pairs of legs, outside the case, drag it along. It does not spin a web of silk over the food material but eats clean-cut holes, not usually in one spot. Females live about 30 days and lay 100 to 300 eggs. The larva stage lasts 50 or more days, and the pupal stage is passed in the case or cocoon. There are about 2 generations per year.

**CONTROL AND MANAGEMENT OF CLOTHES MOTHS**

- Dry-clean all woolens that are in need of it
- Advocate that clients inspect all wool products in storage and discard those unlikely to be used.
- Where there is sudden activity of flying moths, look for areas where water leaks have brought about increased humidity. Then have all areas with high humidity ventilated or dehumidified.

Make spot application in storage areas with approved pesticides. Apply naphthalene or paradichlorobenzene (PDB) flakes at the labeled rate to tight chest garment boxes and storage bags to concentrate, and hold vapors. PDB crystals vaporize much faster than naphthalene and must be maintained to ensure protection. Do not allow continued breathing of either of these pesticides.
LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Be able to identify silverfish and firebrats based on their appearance and recognize the signs of silverfish damage
- Be able to identify key features in the life cycle, habits, and habitat of silverfish and firebrats
- Know the steps needed to effectively control and manage silverfish and firebrat pests

Silverfish and firebrats are among the most ancient of insects. They were on earth before insects developed wings. These pests were among the most common insects in homes and businesses when wallpaper was the usual wall covering and when coal furnaces had glued, taped, insulated pipes.

Silverfish and firebrats are the most common representatives of the “bristletails”. Pest bristletails are about 1/2 inch long as adults and unlike other insects, they continue to molt when full grown and may shed their exoskeletons as many as 50 or 60 times. They have long antennae in front and three antenna-like processes on the abdomen, they are broadest in the front and gradually taper toward the rear. In general, they shun light and prefer dark, undisturbed sites.

COMMON SILVERFISH
(*Lepisma saccharina*)
The silverfish is about 1/2 inch long when full-grown and is covered with silvery scales. It prefers temperatures between 70° and 80° F and requires high humidity. Adults can live from two to three years. They feed on starchy substances such as flour, starch, glue, paste, and the starch sizing on textiles and papers. Silverfish can digest cellulose fibers.

Description - Silverfish build up around the material they feed on, such as spilled flour in cupboards, corrugated cardboard boxes in damp basements, insulation glue, and stored books in unventilated attics. Their feeding leaves irregular, yellow-stained holes in sized textiles and paper, surfaces removed from corrugated cardboard and irregular areas grazed off cloth-bound books. Damaged products will often have a dark fungus growing on them because of the humidity and insect fecal deposits.

FOUR-LINED SILVERFISH
(*Ctenolepisma lineate*)
Description – The four lined silverfish is about 15 mm long, tannish gray, and has 4 dark lines extending down the length of its back. The young are light brown, and are often tinged with pink until the fourth molt, which occurs a month or so after hatching.
This species occurs in the eastern United States as far south as Georgia and Arkansas and in California as well. This species is not limited to distribution in a building by temperature and moisture conditions as the silverfish already mentioned and the firebrat. *C. lineata* can be found throughout the house and in the basement, in wall voids, and in the attic, where it is often seen in large numbers, particularly in houses with roofs of wooden shingles. It occurs in the mulch of flowerbeds around the foundation, and in the garage, even if it is not attached to the house.

**Life Cycle** - The silverfish can be an outside pest or transported into the structure in cardboard boxes and books.

The silverfish lays 1 to 3 eggs per day or close to 1,000 per year. She places these eggs in cracks and crevices, under objects and sometimes, just leaves them exposed.

They need heat (72 to 90 degrees) and moisture (relative humidity of 50 to 75%) to hatch. It takes 3 to 4 months from hatching to adulthood. Most silverfish can live up to 3 years.

**FIREBRATS** *(Thermobia domestica)*

**Description** - Firebrats are not silver but mottled dark gray and dull yellow. Their distribution, size, shape and appendages are like those of the silverfish, but firebrats prefer decidedly higher temperatures and surroundings warmed to 90° F or more. Examples of firebrat habitats are bakeries, where heat and starches are prevalent; furnace rooms; steam pipe tunnels; attics; hot apartment bathrooms and partition walls of water heater rooms.

**CONTROL AND MANAGEMENT OF SILVERFISH AND FIREBRATS**

- Locate moisture sources
- Mend pipe leaks
- Ventilate closed rooms, attics, and crawl spaces
- Dehumidify humid spaces
- Eliminate standing water
- Make changes in grade and gutters where water runoff causes damp basements and walls
- Eliminate stored material that harbor bristletails
- Dispose of infested storage boxes and relocated stored materials in dry spaces after inspection of materials
- Trim trees where shade is causing moist conditions on roofs and roof eaves
- Use crack and crevice application of appropriately registered pesticides in areas of infestation to kill newly hatched bristletails
- Use dust as spot treatments where it will not drift. Dusts can also be used in crack and crevice applications
- Use naphthalene flakes in sealed textile storage for protection of materials
- Use fogs to eliminate heavy populations and to keep the active, exposed pests from migrating into new areas
FLEAS, TICKS, BED BUGS AND MITES

LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Understand the cat flea life cycle and how it contributes to flea problems
- Be able to discuss habitat alteration and why it is needed
- Be able to identify pesticide application methods for flea control
- Understand when, how, and why insect growth regulators (IGRs) are helpful

CAT FLEA
(Ctenocephalides felis)

**Description** - The secret to flea population management is the flea’s life cycle. The adult must contribute timely nourishment for larvae under special conditions, or the young will not survive. No longer a regional problem, today’s fleas are common in all parts of the country except very dry areas.

The most important species that pest control application must manage is the cat flea. The cat flea feeds on a variety of hosts, including cats, dogs, raccoons, rodents, foxes, opossums and humans. This flea prefers pets and will not affect humans unless populations are excessive or the pet is removed from its resting areas. It is common for families to remove their pet while on vacation and then return home to find ravenous fleas.

Time away from home may result in the following sequence of events:

- A summertime vacation will not stop flea-development
- Taking the pet removes the main host
- While the family is away, larvae continue to develop, feeding on dried blood. Pupation occurs in debris-covered cocoons, requiring a minimum of one week for production of pre-adults and adults.
- The family returns to the newly emerged adult fleas ready to feed and accept ALL available warm-blooded hosts.

**Life cycle - Eggs**

After feeding on blood, an adult female flea will lay up to several hundred eggs within three weeks. Flea eggs develop in pet resting areas in warm, humid climates. The tiny flea eggs are very smooth and rounded. They do not stick to pet hair and are easily scratched or shaken off. When they fall on the pet bedding, furniture, carpets, etc, they shake down to the same level as the pepper-like dried blood excreted by feeding adults. These eggs will hatch in one week to ten days.

![Figure 12.1 Cat flea egg and larva (Image courtesy of Micrographia)](image)

**Larvae** - Larvae are tiny, worm-like and whitish (almost transparent) with small brown heads. When larval fleas hatch, they are only 1/6 inch long. After three molts, they grow to nearly 1/4 inch but are still difficult to see. The entire larval stage may take only one week under favorable conditions, or it may be prolonged over several months.

The legless larvae can disappear with remarkable speed (into carpets and pet bedding, etc.) moving by using a pair of spines at their rear and hairs on each segment. Flea larvae are scavengers and do not suck the host’s blood or
live on the host. Cat flea larvae have chewing mouthparts that they use to eat specks of dried blood. When they are full, the blood turns them to a near-purple color.

Like many insects that live in large populations (e.g., pantry pests), mature flea larvae crawl away from the area where they develop and work their way into cracks or under the edge of pet beds, rugs, or carpeting. These mature larvae spin a loose, white silken cocoon in which to pupate. The cocoon often is covered with dirt particles and other organic matter during its construction.

**Figure 12.2 Cat flea cocoons (Image courtesy of the University of Florida)**

**Pupae** - Shortly after making the cocoon, the larva molts and forms a white pupa. The pupa becomes an adult but does not emerge immediately. Rather, it remains immobile in a form called the “pre-adult” stage until stimulated to leave the cocoon. This pupal stage is completed within seven to ten days. The pre-adult form may remain in the cocoon for months.

Various stimuli guarantee the flea will leave the cocoon only at a favorable time: being stepped on by the pet, carbon dioxide being exhaled by a host, or encountering a sufficient number of warm, humid days. The adult flea is ready to feed as soon as it leaves the cocoon.

**Figure 12.3 Adult Flea (Image courtesy of Oklahoma State University)**

**Adults** - Adult fleas live on the pet and in the pet’s sleeping or resting area. Adult fleas are parasites. They get their nourishment from an animal host, usually a mammal. They feed by biting and sucking blood, sometimes daily, or two or three times a week. Most feeding takes place while the pet is sleeping or at rest.

Fleas inject irritating saliva when they feed. The bite irritation causes the host to scratch and shake, dislodging the eggs. The females digest the host’s blood and excrete a corkscrew-shaped string of black, nearly dry blood. This fecal blood breaks up into pepper-like specks that are also scratched off into the pet sleeping or resting areas. Cat flea larvae cannot live without dried blood from the adults so flea development sites are not evenly distributed throughout a home or building. The larvae use this dried blood as a food source.

**FLEA BITE AND FLEA ALLERGY**

Secretions of saliva that prevent the host’s blood from coagulating accompany the flea bite. The saliva contains several chemicals that cause irritant reactions such as hypersensitivity to subsequent flea bites. This sensitivity often results in flea allergy dermatitis, expressed by hair loss, excessive scratching, skin inflammation, etc.

The bite distribution pattern in dogs and cats begins across the hips near the tail and narrows along the back. An area between the hind legs and on the belly can also be affected. Cats are less affected on the belly than dogs but often have problems on the neck or collar. Once the allergy is activated, reaction is quick with few subsequent bites. Flea allergies also seem to be hereditary.

Flea infestations and reinfestations are common in all parts of the country except very dry areas. If there is an infestation of fleas, the inside as well as suspected flea development sites in shaded, humid zones outdoors where host animals lounge; these zones should be treated to gain control. Fleas may enter living spaces from raccoon harborage and nests in attics and chimney flues. In such cases, flea control can be achieved only by raccoon exclusion and harborage treatment.

**CONTROL AND MANAGEMENT OF FLEAS INSPECTION**

**Indoor** – A close inspection of a structure will principally involve finding the “hot spots” or areas of high flea development. Pet bedding or sleeping areas should be identified first. Pets do not sleep or rest indiscriminately or randomly in a structure. They have favorite places and move among them throughout the day. Where they habitually stop and rest, flea eggs and dried blood accumulate. These are spots where they habitually scratch, bite, or shake (e.g., after leaving a resting spot). Spots where cats land as they jump down from a high resting or feeding area are also places where eggs and dried blood fall. Inspect fireplace hearths for possible raccoons nesting above damper.
Outdoor – Kennels and doghouses are obvious places where fleas build up. However, there are other places where pets prefer to sleep or rest at certain times of the day. Examples are under particular bushes, under porches, or in crawl spaces. If a pet roams the perimeter fence, points of infestation might be located there.

Outdoor flea infestation rely on dependable hosts and warm, humid climatic conditions. Flea larvae require moisture because they easily dry out and die. Neither can they tolerate free water (such as rainwater), or they drown. Therefore, infestations are not found in unprotected or not well-drained situations.

Reinfestation from Outside – Some species of urban wildlife harbor cat flea populations. When urban neighborhoods mature, their habitat for wildlife increases. Raccoons have long been prominent and over populated some urban areas. They live in chimneys, large trees, and storm sewers. Chipmunks, grown squirrels, and domestic rodents have also found habitat in ivy terraces, rock walls, soil berms, and underground drainage areas. The opossum has extended it range and is one of the most common urban wildlife species found in Ohio today.

Pets are always aware of the location of wildlife habitats in their own backyard. As soon as they are released, they run to these places to investigate even if they cannot get to the animals. This behavior ideally facilitates flea reinfestation of clean pests.

HABITAT ALTERATION
Indoor – Flea populations build up in the warm, humid weather of spring and summer and decline to low levels in cool or dry winter weather. Maintaining low humidity indoors will hinder the buildup of flea populations.

When focus areas of flea populations are identified, these and other potential harborage sites should be vacuums as thoroughly as possible. Except for flea allergy dermatitis, which can be initiated with very few flea bites, a moderate flea population can be kept at a tolerable level by vacuuming alone. This vacuuming is augmented by use of insect growth regulators labeled for control of fleas.

Reduction of clutter facilitates inspection and permits effective pesticide application. Pests and feral animals should be kept out of crawl spaces, chimneys, areas under porches, and outbuildings. Eliminating the wildlife habitat where fleas are harbored, and trapping or killing of animals responsible for reinfestations, may become essential in stopping difficult flea infestations. Care should be taken; however, do not rely on wild animal elimination alone. Other wild animals move in from adjacent ranges. Consult ODNR regulations when dealing with wild mammals.

PESTICIDE APPLICATION
Treatment of Pets – the pet owner or a veterinarian should treat pets. Where flea allergy dermatitis is, veterinarians must treat involved pets or recovery will be slow at best. Pet bedding should be washed once a week. The pet kennel or pet box should also be cleaned and washed each week. The weekly schedule kills eggs and larvae and eliminates the dried blood essential for complete larval nourishment. Pet owners can purchase pesticide spot-on products, shampoos and sprays, which should be used according to label information. Veterinarians prescribe systemic insect growth regulator medications and perform “Dipping,” both of which are effective on pets. Flea collars may help with some flea infestation, but they are generally the least effective treatment.

Treatment of puppies and kittens with certain shampoos and sprays can be hazardous. These small pets should be moved out of infested areas into clean bedding and their mothers carefully treated. Children should not fondle pets treated with pesticides. Medicated ointments can be used on pets, especially dogs, with severe flea allergy dermatitis.

Indoor – Never apply pesticides until thorough vacuuming has been completed.

Insect growth regulators (IGR) have proven very efficacious in flea control. Growth regulators interfere with or replace natural hormones essential for the flea larvae to change into pupae and reaching adulthood. IGRs have long residues and a good margin of safety for humans. IGRs do not affect the pupae or adults, so fleas that have reached those stages complete their development.

Spot treatments with pesticides are applied to kill flea larvae and adults that are exposed to the sprays. These pesticides (e.g., microencapsulated pesticides, emulsifiable concentrates, dusts, and space sprays) have varied residual periods. The “pre-adult” under adverse conditions (cool or dry weather) may not leave the pupal cocoon for a period of weeks, even months. This means that some fleas will be spared treatments until after pesticides have lost their effectiveness.

Carpet staining or color alteration can occur from pesticide use. The sprays should be applied as even fine overlapping fan sprays under low pressure. Avoid over-wetting carpets. During very humid weather, carpets dry slowly and ventilation or dehumidifying is necessary. Sprays will not reach larvae or adults deep down in the carpet. The flea adult and larvae will be exposed to the pesticide residue when they move up or out of the nap. Some respiratory action may kill pests as the pesticide dries. Do not allow pets or children on the treated carpet while it is wet. Contact with the treated carpet will also help kill adult fleas on an infested pet.
**Preventive Treatment** – Preventive treatment is critical, especially where flea infestations were particularly severe the previous year. In addition, preventive treatments are critical when animals are in poor health, flea allergy dermatitis must be avoided, and where outside infestation can be predicted. If IGRs are to be used alone, they should be applied before spring flea activity gets underway at least one month before flea problems are even noticed. IGR application can be repeated according to predicted need.

When summer visitors bring their infested pets, a flea infestation can be anticipated. Thorough vacuuming is recommended but where previously uninfested pets are involved preventive treatment with an IGR might be indicated.

**Outside** – Where pet reinfestation brings on repeated inside infestations, the outside environment should be treated. Random outside treatment of full lawn cover sprays are not as effective as careful treatment of pet resting areas and wild animal habitat.

Kennels, dog runs, and doghouses are obvious areas to treat. Perimeter fences where pets and wild hosts roam may be the pest interface between one yard and another. Crawl spaces, areas under porches, and opening into basements and attics where pests or wild animals nest should not be closed off until the animals are removed and the areas adequately treated.

Emulsifiable concentrates or microencapsulated insecticides can be applied as spot treatments where labels permit. Emulsifiable concentrates of many pesticides have a short residual when exposed to outside light and weather fluctuations.

Pesticides should be reapplied when rainy weather follows initial pesticide application.

**PARASITES**

An organism that lives in or on another and gets its food during all or part of its life without directly causing it death is known as a *parasite*. The organism from which the food is taken is called the *host*. Many of the biting pests discussed in this chapter will feed directly on humans and other warm-blooded animals. These parasites are blood feeders. Some may carry disease-causing organisms like bacteria and viruses from one host to another. When parasites carry diseases and pass them on from host to host, they are *vectors*. Ticks are especially known to be vectors of some serious human diseases.

In many of the pest situations discussed in this chapter, pesticide applications will not be necessary. Habitat alteration is often all that is needed to manage biting pests. It is important that pest control applicators understand the habits, life cycles, and disease-vectoring capabilities of biting pests so that clients receive the proper advice.

Ticks and mites are in the arachnid order Acarina. Many new mite species are found and described every year. They have sack-like bodies rather than segmented bodies like scorpions. Unlike spiders, which have a combined head and thorax where the legs attach followed by an abdomen, mites and ticks have only a single (one part) oval body with legs attached to its sides.

Ticks and mites have four stages in their life cycle: egg, larva, nymph and adult. All first-stage tick and mite larvae have only six legs; both later stages, nymphs and adults, have eight.

Ticks, the largest mites, feed on the blood of mammals, birds, reptiles, and amphibians. Ticks differ from other mites. Ticks are larger and have curved teeth or ridges on the central mouthparts called the *holdfast organ*.

They also have a sensory pit on each of the first pair of legs. This pit detects heat and carbon dioxide. Ticks also detect light and dark as well as shapes, shadows and vibrations. All of these stimuli help ticks find their hosts.

There are two types of ticks: soft and hard. Soft ticks feed on hosts then return periodically to a nest or shelter. Hard ticks are found on pests, cattle, wildlife and people. In the United States, campers, hikers, and hunters are sometimes hosts for hard ticks.

Some ticks live their life on one host. Other tick species spend only their larval and nymphal stages on one host and the adult drops off to find another host. Most ticks have three hosts, one for each stage.

**Life cycle** – Female ticks normally give rise to thousands of tiny seed ticks (larvae) which hatch from a batch of eggs. Immediately they disburse throughout the surrounding area. Fortunate ones attach to a small mammal or lizard. These larval ticks, called seed ticks, suck blood. Because they are small, their feeding times last only hours or a day or two. While ticks feed, the host wanders and the ticks are distributed away from the initial site. When engorged, seed ticks are usually still in or near an animal run.

**Nymph** – After molting, the engorged nymph climbs grass or a plant stem. As ticks develop, they climb higher to find a larger host. Again, the nymph engorges and then drops off its host and molts.

**Adult** – The tick climbs vegetation, stretches out its front pair of legs, a process called “questing,” and waits for vibration or a show announcing a nearby host. Ticks sometimes wait for months or more than a year for a suitable host. According to one report, a soft tick lived for 11 years without feeding! If heat or carbon dioxide is detected, the tick will seek it out. As the host passes by claws located at the tips of the
tick’s legs grab hold of the host. The tick moves into the fur or feathers to a place where it can engorge.

Attachment and feeding - Adult female hard ticks will feed for several days to more than a week. Anyone who removes an engorged tick gains a respect for the parasitic tenacity of this pest. Since ticks cannot fly or jump and do not crawl up high shrubs or trees, they grasp human hosts close to the ground. The ticks grasp them on the shoe, ankle, or lower leg and crawl upwards until constricted by tight clothing or until they reach the head. On wild mammals or pests, they often move until they reach the highest point on the host, the head or ears.

The tick’s ability to creep undetected is matched only by its ability to attach for feeding without the notice of the host. Stealth keeps ticks from being scratched off by the host before they can attach.

The tick slides its pair of slender teeth painlessly into the host’s skin and feeding attachment begins. The central holdfast organ covered with recurved teeth or ridges is inserted and blood sucking begins. Secretions from the tick’s salivary glands are injected into the wound. These secretions form around the holdfast organ and glue it in place. At this point, the tick cannot voluntarily detach until feeding ceases and the secretions stop.

The strength of the holdfast organ helps the tick resist host scratching. The organ’s importance increases as feeding proceeds because as the female tick engorges, she cannot hold onto the host with her legs alone.

Female feeding may take several days to a week or more. With the case of human hosts, feeding might continue until the tick is discovered. When feeding is complete, the engorged female drops off the host, lays her eggs, and then dies.

Male ticks are on the host to mate. They do not enlarge greatly or feed much. They sometimes pierce and feed on the engorged females.

The brown dog tick (a.k.a. kennel tick) is the most urban of the pest ticks in the United States. In the United States, their only hosts are dogs. In the southern states, this tick lives outside all year round. In most of the country, it cannot live outdoors in winter. The brown dog tick is unusual among ticks because it can complete its entire life cycle indoors.

Adult ticks are about 1/8 inch long and uniformly dark red brown, differing from the other pest ticks that have a red and black or white and brown color variation. The engorged female becomes a dark blue gray because of her blood-stretched abdomen.

The female can deposit up to 4,000 eggs. When the eggs hatch outside, larvae climb vegetation. When the eggs hatch inside, they climb walls and furniture. The larvae, nymphs, and adults return to the dog to feed. The brown dog tick rarely attacks humans. If they do not find a host, they can easily wait more that six months without feeding.

After each engorgement, the tick drops and crawls to a crack where it molts. After a generation or two, ticks can be found at all stages, hiding, molting, or seeking a host. One to four generations can be produced each year, depending on the availability of hosts and the temperature. Infestations in dwellings have the capability of exploding to very high levels quickly.

Infestation – Homes and yards can be infested by the visit of an infested dog that drops mated, engorged female ticks. Other dogs can become infested when they are taken to an infested kennel or a home where ticks successfully attach.

Outside dogs encounter ticks that live outside. When the dog spends more time indoors in late summer or fall, female ticks will drop off indoors, lay eggs, and their larvae will emerge indoors late, that fall. Ticks usually drop off when the dog is sleeping. Its sleeping areas will probably have the most severe infestations.

CONTROL AND MANAGEMENT OF BROWN DOG TICKS

Start by looking in rooms where dogs sleep, under the edges of rugs, and furniture, in cracks around baseboards, windows, and doorframes. You should also check in dog beds.

- Check pets regularly for ticks.
- Treat pets using pesticidal dips, washes, or dusts. **Do not let small children play with dogs that have been recently treated.**
- Wash dog bedding frequently.
- Evaluate flea and tick collars. Effectiveness is variable.
- Keep grass cut short around buildings and fences. Mow on both sides of fences.
- Keep stray dogs out of the yard.
- Use crack and crevice pesticide application where ticks hide.
- Treat under the edges of rugs, under furniture, in cracks around baseboards, windows, and doorframes. You should treat in dog beds.
- Do not allow pets or children in the sprayed area until it is dry.
- Fogging for ticks is useless.
- Spray or dust kennels and resting areas using pesticides labeled for that treatment.

**TICKS THAT CARRY DISEASE**

**AMERICAN DOG TICK**

(*Dermacentor variabilis*)

![Figure 12.5 American Dog Tick Female (Image courtesy of University Nebraska – Department of Entomology)](image)

The American dog tick larvae and nymphs attack small mammals. The adults attack larger mammals like dogs, horses, and humans. Larval and nymphal stages prefer small rodents (especially the short-tailed voles) called meadow mice.

**Description** - Only the adults that are slightly over 1/8 inch long are on dogs and humans. The adult female is brown with a pearly light anterior dorsal shield. Males are brown-backed with pearly streaks. Both sexes have eyes or unpigmented light-receiving areas at the edges of the shield.

**Life cycle** - With a favorable food supply, American dog ticks complete their life cycle in about three months. The female will usually lay up to 6,500 eggs in late summer. Warm springs promote early adult and larval activity and egg laying.

Adult ticks usually contact people on the lower extremities and crawl upwards until constricting clothing such as belts or underclothing stops them. Loose clothing worn by children allows ticks to proceed as far as the head hair. This is probably why people think ticks drop out of trees, which is false. Because of possible transmission of RMSF (Rocky Mountain Spotted Fever), you should note any tick attachment and the victim should be observed for symptoms.

**BLACK LEGGED TICK OR DEER TICK**

(*Ixodes scapularis*)

The deer tick is unlike the larger American dog tick. Larvae are no larger than the period at the end of this sentence. Nymphs are close in size to the adult at a little less than 1/6 inch or the head of a pin. Adult deer ticks are about the size of a sesame seed. Deer ticks have a two-year life cycle and utilize three different hosts.

![Figure 12.6 Black Legged or Deer Tick (Image courtesy of the University of Nebraska – Department of Entomology)](image)

**Eggs and Larvae** – Adult tick females that have over-wintered lay eggs in the spring. Tiny larvae hitch and feed on white-footed mice and other mice in the late summer. *Larvae can feed on humans but will not transmit Lyme disease.* Larvae over-winter and in the following spring they molt into the nymphal stage.

**Nymphs** – Nymphs are ready to feed in May and June. The body of the nymph is tan with black legs and a black shield (scutum) near its front. Nymphs climb vegetation and attach to passing animals such as dogs, cats, horses, cattle, raccoons, opossums, migrating birds, and humans as well as mice.

Nymphs live in what is called the “white-footed mouse habitat”. The larvae of these nymphs fed here the previous summer. The habitat described as woodlands has bushy low shrub edge regions and grassy areas that border them. This is a deer habitat as well. The mice travel in trails and nest almost anywhere they find shelter. Nymphal tick activity coincides with human outdoor activity. The peak human symptoms occur in early July. Ninety percent of the human Lyme disease cases are the result of nymphal tick feeding. The remainder is due to adult activity. Nymphs usually molt into the adult stage in late summer. They sometimes over-winter and molt in the spring.

**Adults** – The body of the adult female is brick red with black legs. She has a black shield (scutum) in the front. The male is entirely dark and smaller than the female.

Lyme disease does not affect deer when these ticks feed on them. The distribution pattern of the next generation is determined when the egg-laying females drop off the hosts. Adults feed in late fall or spring. Deer ticks also
bite on warm days in winter. Hosts of the western-blacklegged tick are dogs, cats, sheep, horses, cattle, and deer.

**DISEASES AND TICKS**

Several species of hard ticks are significant human disease vectors (or carriers). They are responsible for the spread and increase of Lyme disease and the persistence of Rocky Mountain Spotted Fever (RMSF). All applicators should be familiar with Lyme disease and the Ixodes ticks that transmit it.

The large urban population in the United States is becoming increasingly at risk of tick-borne diseases. Humans are closer to diseased ticks because of:
- Reversion of farmland to scrub vegetation
- Continuous incorporation of rural land into urban population centers
- Frequent travel to rural areas for recreation and vacations

Wildlife populations, hosts for tick-borne diseases, are increasing in both rural and urban areas. In addition, urban tick populations are not susceptible to classical agricultural pesticide applications. There are many reasons why ticks are successful parasites and successful at transmitting diseases.
- They are persistent bloodsuckers that attach and hold on
- Long feeding periods allow time for infection and extend the distribution time
- Many species have a wide host range. Initially, ticks feed on small hosts and then on larger hosts. Most can take three different hosts. They primarily find mammals but accept birds and reptiles
- They have a tremendous reproduction potential and lay several thousand eggs
- Eggs of some disease carrying ticks also carry disease
- They have few natural enemies. Only two species of wasps parasitize hard ticks.

**LYME DISEASE**

Lyme disease is caused by a spirochete, which is a spiral-shaped bacterium. Symptoms vary and may mimic other diseases. For this reason, many cases go undiagnosed. The first indication of a potential infection may be the discovery of an attached tick. *Disease transmission does not occur for an estimated 10 to 12 hours after feeding begins. If you find the tick, have it removed within the required period. NO Lyme disease infection will occur.*

Usually within 7 days (from 3 to 32 days) after disease transmission, a rash appears in 60 to 75 percent of all cases. The rash looks like a red expanding ring and may burn or itch. Technically, this rash is called erythema chronicum migrans (ECM). It is not uncommon to find ECM at multiple sites. It disappears within three weeks but can recur.

Other skin symptoms may be hives, redness of cheeks under eyes, and swelling of eyelids. There may be a reddening of the whites of eyes as well. Flu-like symptoms may accompany the skin symptoms. These are high fever, headache, stiff neck, fatigue, sore throat, and swollen glands.

A second set of symptoms occurs in untreated patients four to six weeks after transmission. Over half of untreated victims of Lyme disease experience arthritis of the large joints (primarily the knees, elbows, and wrists) intermittently or chronically.

A few (10 to 27 percent) experience neurological effects including severe headache, stiff neck, facial paralysis, weakness and possibly pain of the chest or extremities. These may persist for weeks. In 6 to 10 percent of the cases, heart block may occur.

Dogs can also acquire Lyme disease when they forage in a tick habitat. Diagnosis of the disease in dogs in an area is an indication of human cases to follow. Symptoms in dogs include sluggishness and lameness.

**RESPONSES TO LYME DISEASE; EDUCATION**

This serious disease is expected to increase. Applicators should clearly instruct their clients that easy effective control measures do not exist for ticks.
- Children are at highest risk because infected ticks are often encountered in camps, parks, on hikes, or in play areas where deer and mice are common around.
- The second risk group consists of adults whose occupation places them in thick habitats. They are farmers, outdoor maintenance workers, park and forestry personnel, and military personnel.
- Members of the public who hike, camp, participate in outdoor recreational sports, or live in areas of preferred tick and host habitats are the third risk group.
- Hunters, depending on the amount of time spent outdoors, fit into either of the last two groups.

**ROCKY MOUNTAIN SPOTTED FEVER (RMSF)**

RMSF is caused by rickettsia, a disease organism related to bacteria. It is an acute infectious disease characterized by pain in muscles and joints, fever, and spotty red skin eruptions.

*Note: After the American dog tick begins feeding, at least four to six hours elapse before the transmission of the disease is initiated. If you remove the ticks during this non-infective period, infection WILL NOT occur.*

A rash on wrists and ankles is the most common characteristic and consistent symptom of RMSF, which
occurs on the second to the fifth day after infection. Often aching in the lower back, headaches, and pain around the eyes will also occur. Victims feel very tired and can run fevers of 104° to 106° F. Less obvious symptoms may not be noticed.

Laboratory blood tests can be done to assist diagnosis in questionable cases. Early treatment using antibiotics is most successful.

CONTROL AND MANAGEMENT OF DISEASE CARRYING TICKS
Where pest management services are provided to an area such as a neighborhood, camp, park, zoo, government installation, or similar facility, it is important to determine the kinds of ticks that are present. Where are these ticks most numerous? What is the disease potential of the area? Know the hosts and reservoir populations. Pest management programs are critical for effective management of tick species that transmit Lyme disease or Rocky Mountain spotted fever.

- Monitoring with a tick drag: Tie a rope to a 2-foot long wood strip to which a 2x3 feet white cloth rectangle is attached. Drag the cloth through tall vegetation in areas of concern for tick infestation. All stages of ticks attach to the fabric. Collect the ticks and have them identified by OSU Extension or some other service. Small pieces of dry ice placed in the middle of the cloth rectangles have also attracted ticks successfully.
- Visit deer-checking stations during hunting season. Trap mice and count ticks. If governmental agencies or regional health associations are interested, they will test collected live ticks to check their level of infection.
- Consult local veterinarians. They are the first to see Lyme disease cases in an area. Positive disease diagnosis in dogs is a clear signal that human cases will follow.
- Interview game conservation agents to learn host (mice, deer) occurrence. They also have information on disease occurrence in hunters and hunting dogs.

Talk with game conservation personnel about game management practices and game habitat modification. Encourage hunting or other game management practices to reduce the deer population in infested areas. Previously restricted areas may need to be opened to hunting.

- Reduce the rodent habitat to reduce hosts for larval and nymphal ticks
- Open up woodland edges to provide observation perches for hawks (mouse predators) and reduce edge browse for deer
- Protect owls and hawks from hunters
- Support cleaning up corn left in the edge rows of fields and grain spills around storage bins and roads
- Widen paths in camps and parks to keep walkers away from plants from which ticks can make contact with humans
- Advise that uncontrolled areas with high tick density be kept off-limits to the public

A novel control measure using permethrin-treated cotton balls in cardboard cylinders has been reported to reduce tick populations. White-footed mice use the pesticide treated cotton as nesting material. The pesticide does not harm the mice but kills their tick parasites. This device must be placed early enough to catch larvae and nymphs and must be placed close enough to reach all the female mice.

- Pesticide sprays are most effective when applied to the sides of paths.
- Mow low vegetation including low shrubs thoroughly.
- Mow around weedy fences that provide cover for rodents moving in from nearby woodland edges. Spray at their base.
- Use herbicides to control grasses and herbaceous weeds where mowing is impossible. Remember broad application of herbicides to mowed grass does not reduce tick populations because white-footed mice do not infest lawns.
- Dust rodent burrows in areas where human traffic can be controlled.

To control ticks on pets:
- Use insecticidal dips, washes, or dusts that can be obtained at pet stores or from vets. Dogs should be protected if they roam in thick habitat.
- Encourage regulating all uncontrolled or ownerless dogs.
- Use of flea and tick collars has variable results.
- Cats do not appear to be at risk from Lyme disease nor are they hosts for RMSF vectors.

BED BUG (Cimex lectularius)

This wingless bed bug is a blood-sucking parasite of humans and has moved with us all over the world. The bed bug’s adaptation to humans is so complete that their bites are nearly painless. These pests were disliked more than cockroaches at one time.
Bed bugs were once thought of as nearly eradicated in the United States. Now they are back in four-star hotels as well as private homes. If you have an infestation, it does not necessarily mean you are unclean, as popular belief would have it. Yet, clutter will give them many places to hide. Bed bugs are known by several other names such as wall lice, house bugs, mahogany flats, red coats, chinches, crimson ramblers, as well as others.

Bed bug populations had dropped to low numbers because of DDT and other residual and broad-spectrum insecticides used in the past. These insecticides are not available now. These pesticides were used for multiple insects. Now, baits for insects such as ants and cockroaches are used, while indoor applications of residual insecticides have become less popular. These practices do not control bed bugs, so they increase. Also, more people than ever travel abroad so bed bugs hitch a ride in bags, on clothes, etc., and come to the states.

Description - Bed bugs have oval and flat bodies. Their color is reddish-brown. Their heads are short and broad. Adults are 1/8 to 3/16 of an inch. When adult bed bugs feed, they swell slightly in size. They also darken to a blood-red color. Nymphs have the shape of adults but they are yellow-white in color. Bed bugs can be seen by the naked eye.

Hosts include many species of vertebrates besides humans including poultry, rodents, dogs, and cats. They infest shelters along hiking trails and cabins of summer camps and parks. Sometimes, occurrence of bed bugs in urban homes can be traced to these facilities.

Life cycle - Eggs – Bed bug eggs are 1 mm (about the size of two grains of salt) long. They are very hard to see on most surfaces. Eggs have a sticky coat and are laid in cracks and crevices. They hatch in about 6 to 17 days.

Nymphs - Newly hatched nymphs feed as soon as possible. They look like the adult but have a milky-white tone. A bed bug nymph goes through about five molts before it becomes an adult.

Adults – Adults can normally live about a year or less. Bed bug reproduction is rapid in homes and businesses. Their ideal breeding temperature is between 70° and 85°F. Bed bugs breed inside year round.

Bed bugs do not fly or jump. They are able to enter very small locations in structures because of their flattened bodies.

Bed bugs can live several weeks or months with no feedings. Adults and young can go with no feedings for 80 to 140 days. Older bed bugs can go with no feedings longer than the younger ones. Older adults are known to live as long as 550 days with no feedings. That is about 18 months.

Fertilized adult female bed bugs can lay about 1-5 eggs per day. This is about 500 eggs per her lifetime. They hatch in 7-10 days. From egg hatch to adult, it usually takes 1 ½ -2 months. You can see why bed bugs multiply quickly. A thorough inspection for a suspected bed bug infestation has to be done. Bed bugs are small and hide in many places. They hide under wallpaper, behind picture frames, in electrical outlets, inside box springs and mattresses, in many other places as well. The more clutter, the more places they have to hide.

Inspect the bed frame, box springs, cracks and crevices of the mattress and the furniture. They can be hiding anywhere. Make sure you check all of the structure and its contents.

CONTROL OF BED BUGS
Control of adults, young, and eggs is very important when you have a bed bug infestation. If adult or young females and males are still alive, they can mate and multiply quickly. If eggs survive, they can hatch, mature, mate and multiply quickly.

Total eradication is required for total control of bed bugs. There are several products for bed bug control on the market. They range from ready-to-use to fumigants.

It may take several insecticide applications to gain control of bed bugs. To be successful, reduce clutter and inspect the places where bed bugs hide. Use a vacuum to get rid of the bed bugs you find.

BAT BUGS (Mites) (Cimex pilosellus)
In Ohio, you can also find the bat bug (Cimex pilosellus), or chimney swift bug (Cimexopsis nyctalis), so proper identification is extremely important in choosing proper treatment protocols.

Bat bugs and chimney swift bugs are normally found on their hosts. Bat bugs emerging from colonies of bats in the wall voids can cause occasional sightings inside a structure.
If not evident, you should also try to find out how they got into the structure.

**CONTROL OF BAT BUGS**
- Remove chimney swift nests and exclude bats.
- Mention steam treatment to the bedding as a possible alternative.
- If you have bat bugs, excluding bats from structure is very important.
- Make sure there are not bats in the wall voids or attic as this is very important because you do not want to kill any bats in these areas.

**HEAD LICE**
Adult head lice are gray and about 1/8 inch long. Hatching occurs about one week after attachment. Lice go through a gradual metamorphosis so the tiny nymphs resemble the adults. They grow to maturity in about 10 days. Adult lice mate and the female can lay about 100 eggs but often falls short of that in her life of only several weeks.

In the United States, lice live in the head hair of elementary school-age children. Lice are rarely on adolescents or adults. The lice scuttle about on the scalp between hairs with much more speed than might be expected.

**HEAD LICE** *(Pediculus capitus)*
The head lice are locked into the human scalp in several ways. First, louse claws grasp human hair so firmly that they do not wander or fall out of it. Second, head lice suck blood by grasping the scalp with tiny hooks that surround their mouth and painlessly pierce the skin with slender stylets. Head lice feed several times a day but do not become engorged. Head lice neatly glue their eggs (called nits) to the hair shaft within 1/4 inch of the scalp. The tiny pearl-like eggs stick along side the hair so tightly that they can be dislodged only by tearing it from the sleeve of glue by fingernails or fine-toothed comb. Nits found farther than ¼ inch away from the scalp will have already hatched. What is found is the empty shell that remains attached.

How head lice spread is not well known but lice do not roam from child to child. Neither do they wander onto coat collars nor hats because they are so restricted to human hair and the scalp surface temperature of around 80°F. Temperature preference and humidity are critical. Head lice die at elevated temperatures and from excess perspiration. At lower surface temperatures of about 50°F, lice do not move or feed. Most likely, head louse nymphs hatch on hair of infested persons then are scratched or rubbed off by brushes and hats. The next person to use the brush or hat will have the lice. School teachers who are watching for signs of itching heads often discover louse infestations. Classroom neighbors are not as likely to be infested, as are family members and best friends.

**CONTROL OF HEAD LICE**
Several over-the-counter and prescription products are used to eliminate louse infestations. They are all equally effective when used according to label directions.

Prescription preparations are applied only once and have a high probability of killing the eggs as well as live lice. The first application kills all of the live lice. Viable nits hatch in 6 to 10 days and the second application kills that population. These pediculicides are applied to wet hair and after a short waiting period, they are shampooed out. Advise clients to:
- Treat all members of the family who are infested at the same time
- Wash bedding, hairbrushes, and caps in hot water to be sure any nits on fallen hairs are killed
- Vacuum all surfaces where children lie or play (including stuffed toys). In day-care centers and kindergartens, napping mats should be wiped or vacuumed
- Remember: do not apply pesticides to rooms, toys, or furniture surfaces unless they are labeled for control of lice on those sites.

Decisions on the formulation of pediculicides, treatment of head infestations from extensive infestations, and so forth, are decisions to be made by parents and physicians.

A trained medical provider should investigate reported louse infestations of adolescents and adults.
SECTION 3

OCCASIONAL INVADING PESTS

This section covers arthropod species that primarily live outside. These individuals are from the local fauna (a typical collection of animals found in a specific time or place) and invade human habitat but do not reproduce inside. Exceptions to this are spiders and honeybees that inhabit building wall voids.

Pest species in Section 3 are regionally distributed and the pest populations are often cyclic. They may verge on the epidemic for several years and be rare in others. Some pests occasionally enlarge their ranges by expanding into new territories, and from time to time, new ones are introduced from other countries.

Finally, most of the pests in Section 3 must be managed by treatment inside and outside using habitat alterations, cultural changes, pesticide applications, or all of the pest management components. Structural pest management applicators are certain to find these pests interesting and their management challenging.
LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Identify common fly pests
- Describe the life cycle, habits and habitats of common fly pests
- Describe pest management procedures for controlling and managing fly pests, including sanitation, exclusion, and pesticide application

Of the five most serious diseases in the world, flies, including mosquitoes, spread the organisms that are responsible for malaria, sleeping sickness, leishmaniasis, and filariasis. They also are responsible for spreading yellow fever, typhoid, and various diarrheal illnesses. In the United States, the toll of the worst afflictions; heart attacks, cancer and strokes is annually numbered in the thousands. In the tropics, the dead and disabled from fly-borne diseases are counted by the millions. In the United States, flies are considered more annoying than dangerous. As recently as the turn of the 20th century however, malaria and typhoid were major health problems.

Flies, the order Diptera, are one of the largest and most dynamic order of insects. This vast order is characterized by having only one pair of wings. Most flies are small and soft-bodied with two large eyes on the front of its head.

Flies can be divided into two groups depending on the appearance of the larvae and adults.

In Group 1:
- The adults are small – gnat or mosquito-like with long antennae and slender legs.
- Larvae have head capsules and most live in water or moist soil.

In Group 2:
- The adults have stout bodies. Their antennae are short or not visible; some are relatively large but usually not long-legged.
- Larvae do not have discernible heads and are often maggot-like. Their harborage varies – they live in water, filth, soil, carcasses, plant tissues, or animal tissues.

Flies often tell the same story. Flies are found in both urban settings and rural settings. They frequent garbage, dead animals and manure. Their larva lives in that material. To enter a house, they may fly inside through an open door or window, or they have moved from a dead animal in a wall.

LARGE FLIES

HOUSE FLIES
(Musca domestica)

Description - Adult houseflies are about 1/6 to 1/4 inch long with reddish-brown eyes. Females are usually larger than males and have wider spacing between the eyes. They have two membranous wings, sponging or non-biting mouthparts, a dull gray body, and four narrow black-lengthwise stripes on the thorax.

Life cycle - Each female, during her three to four weeks of life, lays five to six batches of 75 to 100 small, white, oval eggs, largely in scattered garbage. The eggs hatch in 12 to 24 hours into creamy white larvae. Larvae grow and pupate in four to seven days. The last larval skin is hard and dark brown, it is called a puparium. This stage lasts seven days and can be the overwintering stage as well. The life cycle
from egg to adult may be from 8 to 12 days in warm weather. House flies have the potential to over run the earth with populations in a season. We are lucky we have predators, parasites, and other factors that reduce house fly populations and help keep them in check.

When feeding, houseflies regurgitate some of their stomach contents on the food, which dissolves it. Then they suck it back into their stomach. They leave fecal deposits where they have walked. While walking and feeding on garbage, fecal material and food, flies may transfer disease organisms from both inside and outside their bodies. The flight range is from two to 20 miles.

GREEN BOTTLE FLY
(Phaenicia sericata)
Green bottle flies are larger than common houseflies. Some have metallic colors such as black (Phormia), blue (Calliphora) and green or copper (Phaenicia). Adults make a loud, droning buzz. The flight range is 3 to 10 miles.

Females lay eggs primarily on confined garbage. These flies are often attracted to dead animals, animal wounds, and feces-caked hair or wool on pets and farm animals. During warm autumn days, adults may gather on doors and window screens and later enter homes for over wintering.

Larvae are commonly found in garbage wastes and pet droppings. Larval development is completed in less than a week for green or copper blowflies.

CONTROL AND MANAGEMENT OF LARGE FLIES
HABITAT ALTERATION
Emphasize sanitation to remove food and breeding sites. If sanitation cannot be improved, other methods of control will not be effective. Make the following recommendations to clients:

- Remove breeding material such as garbage and manure
- Clean garbage cans and dumpsters regularly, and clean up any fresh overflow immediately
- Clean food-delivery spills immediately
- Drain wet areas around garbage collection sites
- Keep loading docks clean

Use exclusion techniques to prevent flies from entering, such as:

- Caulk and tighten around all openings, such as screens, doors, windows, ventilators, and eaves.
- Install air curtains where doors remain open for deliveries, etc.
- Install automatic door closers
- Replace white security lights inside and outside with yellow lights so flies are not attracted to the building
- Fly bait can eliminate adult flies when methods are in place that reduce breeding sites
- Aerosol contact spray can be used to knock down adult flies after elimination of breeding sites and exclusion methods are in effect
- Ultra-low volume dosage application of non-residual pesticides can be used if an adult infestation must be quickly reduced outside

Non-chemical controls include:

- Electric flytraps will control only a low level of adult flies. Watch these traps to see what kinds of flies are being caught
Do not place black light flytraps where they will attract insects from outside. Do not put them in competition with other light, such as those from vending machines, etc.

**CLUSTER FLIES**

*(Pollenia rudis)*

**Image 13.3 Cluster fly (Image courtesy of Van Waters and Rogers)**

**Description** - Cluster flies are found in homes, churches, hospitals, apartment complexes, commercial and public buildings and other structures. These large sluggish flies sometimes called attic flies appear on warm sunny days in late autumn or winter and early spring. They occur in large numbers, especially at windows and in rooms not frequently used. They make irritating buzzing noises, spin around and move sluggishly. When crushed they leave a greasy spot on upholstery, carpets and wood surfaces. Cluster flies in hospitals may carry infectious bacterial on their bodies. They do not bite humans nor feed on structures or furnishings. Buildings or houses located on an exposed hilltop are attractive sites.

Adult cluster flies resemble house flies, but are slightly larger, about 5/16 inch long, narrower and nonmetallic gray. When at rest they overlap their wings at the tips; house flies do not. In addition, the thorax has no stripes but contains many short yellow-golden hairs. The dark gray abdomen is hairy with light and dark patches of color. When crushed the cluster fly has an odor that smells like “buckwheat honey”.

**Life cycle** - Female cluster flies lay eggs singly in soil cracks and crevices near earthworms. Eggs hatch in about three days and the larvae (parasitic stage) penetrate and develop in the bodies of earthworms. The larval stage lasts 13 to 22 days. The pupal stage is from 11 to 14 days. The life cycle is completed in 27 to 30 days. There are about four generations during the summer. Populations vary from year to year sometimes worse after wet summers.

Adult cluster flies move to protected places to hibernate (overwinter) when the days shorten in mid-August. Flies cluster on the warm sides of buildings in late summer during the day. As the sun goes down and the temperatures cool, flies crawl into buildings. The flies crawl in through cracks, especially under eaves, gaps in siding, etc. Large numbers may group together (cluster) in attics, unused rooms, wall voids, basements, tree holes and other darkened sites. They are attracted to light, light-colored siding and structures on lawns and pastures inhabited by earthworms. They enter rooms through sash-cord openings, cracks in windowsills or baseboards, loose fitting vinyl or aluminum siding, and other small openings. They become active whenever temperatures rise above 54° F indoors from early autumn to mid-spring especially around windows with sunlight.

Cluster flies do not breed in buildings but leave hibernation sites in the spring to return outdoors for reproduction activity. Just as they become a nuisance in the fall while seeking hibernating quarters, they are also bothersome in the spring, trying to escape.

**CONTROL AND MANAGEMENT OF CLUSTER FLIES**

**HABITAT ALTERATION**

- Caulk cracks and crevices as much as possible
- Tighten up and caulk around windows and screen ventilating spaces under the roof

**PESTICIDE APPLICATION**

- Use liquid pressurized sprays or dusts where flies have collected in wall voids. Likewise, treat around window and door frames and other cracks and crevices
- Use aerosols or space sprays where large numbers of flies are active. These formulations will control exposed individuals
- Hang sticky fly strips in front of attic windows, especially east windows
- Apply residual pesticides labeled for fly control to surfaces where flies rest, provided those surfaces are not used by people

**SMALL FLIES**

**FRUIT FLIES - VINEGAR FLIES**

*(Drosophila ssp.)*

**Figure 13.4 Vinegar fly (Image courtesy of Andre Karth, Wikimedia Commons)**
**Description** - Vinegar flies may become a nuisance in homes, restaurants, fruit markets, canneries, etc., especially around decaying or rotting fruit and vegetables. Indoors, flies may be seen hovering over ripe fruit and vegetables, baked goods containing yeast, garbage cans and beverages like fruit juices, cider, soft drinks, beer, wine and vinegar. Sometimes you will see flies on a rotten banana, potato, tomato, onion, melon, squash, pineapple or apple. Dirty garbage receptacle, unclean sour mop or dishcloth, empty tomato catsup bottle, or drain water in refrigerators or iceboxes can yield a heavy population of these flies. Outdoors, they become numerous during summer and autumn where fruit and vegetables are harvested and then suddenly disappear when cold weather arrives. Some species are attracted to human and animal excrement also feeding on fruits and uncooked foods serving as a disease carrier.

**Life cycle** - Adult vinegar flies are about 1/8 to 1/5 inch long, dull brownish-yellow to brownish-black. Some species have red eyes. The head and thorax are tan-colored; the abdomen is black and gray underneath. The wings have two "breaks" in the leading edge near the body. The third antenna segment is oval or long with the outer bristle nearly always feathered. Eggs are pearly white. Larvae are about 1/10 to 1/5 inch long, cream-colored, legless, eyeless and tapered to a point at the head end. Larvae have an extended stalk-like breathing tube at the tail end of the body. Pupae are about 1/8 inch long, brown and seed like, with two hornlike stalks at one end. Female flies lay from 500 eggs up to 2,000 eggs singly near the surface of moist, fermenting food material like over ripe fruit, rotten vegetables, dirty garbage containers, slime in drains and waste materials. Eggs hatch in 20 to 30 hours into tiny larvae that feed near the surface of the fermenting food masses. Larvae feed principally on the yeast in the fermenting fluids from five to six days and crawl to drier portions of the food or even out of it to pupate. The larva transforms into the pupa in the last larval skin or puparium. Newly emerged flies are attracted to light. They become sexually active in about two days after emerging. They mate more than once and are strong fliers. The young flies travel up to 6 1/2 miles in 24 hours. The life cycle may be completed in 8 to 15 days depending on temperature. Adults are attracted to yeast growth that cause fermentation. Populations may build up on boxes of cracked tomatoes in the field or on pallets at receiving stations of canneries. This fly has been widely used by geneticists in studies of the laws of heredity since it is very prolific, easy to rear and has a short life cycle. Experiments with radiation-induced mutations in these flies led to the successful discovery of the sterile-male technique for insect control. Eggs laid by females become nonviable after mating with radiation-treated males. Some species of fruit or vinegar flies have been responsible for human intestinal myiasis (a form of diarrhea) common among workers in grape vineyards.

**CONTROL AND MANAGEMENT OF VINEGAR FLIES**
- Close up gaps where flies can enter
- Use small-mesh screening to exclude these small flies
- Discard or clean infested material
- Use precaution to remove the flies before fruit is brought to terminal points when the infestation originates in the field or orchard. Infestation in canneries and fruit markets are very difficult to manage
- Catch plus fruit fly trap
- Pressurized aerosol sprays

**PHORID FLIES**

**Description** - Phorid flies are 1/16 to 1/8 inch long with a hump-backed appearance from the side. They may be black, brown or yellowish. The wings have strong, heavily pigmented veins in the front area, while the remaining veins are faint. The mature larvae measure 1/8 to 1/4 inch long and are spindle-shaped with projections on the rear segments. They are whitish, yellowish-white or grayish in color.

**Life cycle** - Female phorid flies lay their eggs on, in, or close to the larval food. They lay from 1 to 100 eggs one at a time. There are 3 larval stages. In the third stage, larvae crawl to a drier area to pupate. The average developmental time (egg to adult) for two common phorid flies is about 11 days at 85°F and 28 days at 72°F. Adult phorid flies can often be found on flowers or on moist decaying organic matter. Because they frequent unsanitary places, they may transport various disease-causing organisms to food materials.
Several species breed in human corpses and are commonly referred to as coffin flies when they become problems in morgues, mortuaries, and mausoleums. Phorid flies are of great concern in healthcare facilities because of their unsanitary habits, and because larvae have been found in the open wounds of patients. Larvae feed in a wide variety of moist decaying organic matter such as dung, vertebrate and invertebrate carcasses, fungi, and decaying plant material. Common food sources include the moist residue in the bottom of trash receptacles, the moist material found in the cracks and evaporator pans of and under kitchen equipment, in elevator pits, in garbage disposals, in rotting vegetables and meats, dirty moist mop heads, faulty septic systems, and over-watered/rotting potted plants. In health-care facilities and mausoleums, fresh-cut flowers in vases are frequently the source.

In homes, pet stores, and zoos, phorid flies can breed in the urine and excrement-soiled bedding material and bottoms of the animal cages. A particularly difficult breeding source to locate and correct is when sewage pipes leak or break under concrete slabs. The flies breed in the released moist organic matter and saturated soil, and then enter the structure through stress cracks and utility penetrations in the slab.

Phorid flies in mausoleums present a unique challenge because the breeding sources are typically the corpses that are legally protected. The hidden internal drainage system that transports and harbors the body fluids that drain from the corpses and coffins and the cut flowers are phorid fly breeding sources as well.

Some phorid flies are parasites of invertebrates including many insects and other arthropods.

**CONTROL AND MANAGEMENT OF PHORID FLIES**

Carefully identify the infesting fly as a phorid. Locate the area where most flies appear. Ask clients if there have been sewer problems, buried garbage, or decaying vegetable or animal matter close by.

- Remove decaying matter and soil contaminated by it
- Where sewer lines must be repaired, insist that sewage-contaminated soil also be removed.
- Caulk all floor and wall cracks where flies may enter
- Clean equipment

**DRAIN FLIES (Psychoda alternate Say)**

Drain flies sometimes appear suddenly becoming a nuisance in both homes and sewage disposal plants. Adult flies may become so numerous indoors that they congregate at windows, around showers, bathtubs, sinks and floor drains, especially in the basement. Outdoors they mar fresh paint and plug sewage filter beds (intakes and drains). The drain flies get into the eyes, ears and nose of people in the areas. Bronchial asthma can be caused by inhaling fragments and dust of dead flies. Since these flies originate in filthy conditions, there is the possibility of human health disease transmission.

![J. Hahn - Univ. of Minn.](Figure 13.6 Drain fly (Image courtesy of J. Hahn – Univ. of MN))

**Description** - Adult drain flies are tiny 1/5 to 1/6 inch long, fuzzy, dark or grayish insects. Their body and wings are densely covered with hairs. Their antennae are long (13 segments) with each segment having a “bulbous swelling” with a whorl of long hairs. Wings, appearing too large are held roof-like over the body when at rest looking moth-like. Drain flies are weak fliers and make hesitating flights of only a few feet in short jerky lines.

**Life cycle** - Drain flies reproduce in polluted, shallow water or highly moist organic solids. The eggs, larvae and pupae can be found in the muck, slime or gelatinous film often accumulation on the sides of drains, overflow pipes, septic tanks and moist composts. They have also been found in dirty garbage cans, rain barrels and tree holes.

Eggs are tiny, brown or cream-colored and laid in masses of 10 to 200. They can hatch in 32 to 48 hours at 70°F. The eggs are laid in and on the moist media. Larvae are legless about 3/8 inch long wormlike, gray and with both ends a little darker. Larvae feed on the decaying organic matter, microorganisms, algae and sediment in the media. Larvae live in the organic film, breathing through tubes, feeding on sediment, and decaying vegetation. Pupae occur in or on the surface of the breeding media and after 20 to 40 hours, new adults emerge.

The life cycle can be completed in one to three weeks. Adults live about two weeks with old ones dying and new ones emerging. They feed on flower nectar and polluted water. During the day, adults rest
in shaded areas or on walls near plumbing fixtures and on the sides of showers and tubs. Most activity occurs during the evening when these flies are seen hovering about drains and sinks. The may breed in large numbers at sewage filter plants and then may be carried by prevailing wind to nearby homes up to a mile away.

CONTROL AND MANAGEMENT OF DRAIN FLIES
Drain flies do not bite humans but may become a nuisance because of their large populations. Sometimes it takes persistent effort to eradicate an infestation in the home. Concentrate on eliminating larval breeding sites from drains in floors, sinks, bathtubs, etc. Sometimes the source of the problem is a nearby filter plant.

If there are large numbers of drain flies emerging, consider the possibility of a broken sewer line in a wall or under a concrete slab. This can be verified by using a TV camera to view the inside of sewer lines and help localize exactly where the break is located. If a broken line is detected, all contaminated soil must be removed in order to prevent breeding along with repairing the break in the line.

- Use glue boards to locate infestation
- Clean drain and traps with liquid gels containing active bacteria
- A highly selective active bacteria complex, can be used

FUNGUS GNATS
(*Orfelia* spp.)

Fungus gnats occasionally become a nuisance indoors when adults emerge in large numbers as mosquito-like insects from potted plants or flower boxes with soil rich in humus. Adults are attracted to lights and are often first noticed at windows. Larvae feed in soil high in organic matter. The larvae injure the roots of bedding plants. Plant symptoms may appear as sudden wilting, loss of vigor, poor growth, yellowing and foliage loss. Fungus gnats inhabit fungi or dead plant materials and are harmless to humans and animals.

Description - Adult fungus gnats are about 1/8 to 1/10 inch long. They are grayish to black, slender, mosquito-like, and delicate with long, legs, antennae and one pair of wings. Identification can be made by the vein patterns in the wings. Dark-winged fungus gnat adults have eyes that meet above the base of the antennae. Fungus gnat eggs are hardly visible, oval, smooth, shiny white and semi-transparent. Larvae are legless, thread-like, white shiny black-headed up to 1/4 inch long and transparent. Food inside these transparent larvae can be seen through the body wall. Pupae occur in silk-like cocoons in the soil.

Life cycle - Fungus gnats reproduce in moist shaded areas in decaying organic matter like leaf litter. The life cycle is about four weeks with continuous reproduction in homes or greenhouses where warm temperatures are maintained. Broods overlap with all life stages present during the breeding season. Larvae not only feed on fungi and decaying organic matter but on live plant tissue-like root hairs and small feeder roots. Brown scars may appear on the chewed roots. The underground parts of the stem may be injured and root hairs eaten off. Damage occurs most often in greenhouses or plant beds.

Adults live about 7 to 10 days and deposit eggs on the moist soil surface or in soil cracks. Females lay up to 100 to 300 eggs in batches of 2 to 30 each in decaying organic matter. Eggs hatch in 4 to 6 days and larvae feed for 12 to 14 days. The pupal stage is about 5 to 6 days. There are many overlapping generations throughout the year.

CONTROL AND MANAGEMENT OF FUNGUS GNATS
Inspect plants carefully before purchase for signs of insect infestation. Always use sterile potting soil to prevent introduction of fungus gnats. Overwatering, water leaks and poor drainage may result in buildup of fungus gnats. Allowing the soil to dry as much as possible, without injury to the plants, is effective in killing many maggots. Houseplants taken outside during warm weather may become infested with insects before being brought back indoors. Inspect plants carefully and discard if heavily infested and unable to save. Remove all old plant material and debris in and around the home. Practice good sanitation. Electric-light flytraps will attract and kill many adults at night.

Use yellow sticky cards (traps) for adult fungus gnat detection. Place traps just above the plants at a frequency of one per 500 to 1,000 sq. feet. Replace after covered with insects.

- Adult gnats are killed easily with pyrethrins
- Potted plant soil treatments
STINGING PESTS

LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Identify common stinging insect pests
- Describe the life cycle, habits and habitats of yellow jackets, paper wasps, mud daubers, honeybees, bald face and European and brown hornet
- Describe pest management procedures for controlling stinging insect pests

The insects most beneficial to humans are found in the large insect order Hymenoptera. Not only are the bees and their relatives pollinators of plants but some species are parasites of pest insects. Without these parasites, some pests would overtake most crops.

Stinging insects can be one of the most dangerous insects that a pest management professional will encounter. The encounter usually is on a regular basis during the summer months. If you are allergic, be prepared by wearing proper protective clothing and having antihistamines or an EPI pen on hand.

The “pests” of the order Hymenoptera are the stinging insects. Although they are sometimes a danger to humans, yellow jackets, hornets, and wasps also serve our interests because they feed their young largely on flies and caterpillars.

Many of these stinging insects are social. They live in colonies with a caste system or a division of labor and overlapping generations of all offspring of one individual reproductive. Some of these colonies persist for many years (ants, honeybees); others, such as stinging wasps, start a new colony each year.

PAPER WASPS
(Polistes spp.)

Paper wasps, yellow jackets and hornets are in the insect family Vespidae. The common paper wasp best demonstrates the basic building pattern of a colony.

Description - The paper wasp queen is the lone female reproductive that overwinters. She begins her nest by attaching a thick paper strand to an overhanging structure. She then builds hollow paper cells by chewing wood or plant fibers cellulose mixed with water and then shaped with her mouthparts.

Figure 14.1 Paper wasp (Image courtesy of David Cappaert, MSU, Bugwood.org)

Life cycle - When half dozen cells or so are hanging together, the queen lays an egg near the bottom of each one. The little white grubs that hatch from the egg glue their rear ends on the cells and begin receiving nourishment in the form of chewed-up bits of caterpillars provided by their mother. When they grow large enough to fill the cell cavity, they break the glued spot and hang on head down. Mature larvae spin silk caps closing off the cells and molt into pupae. This larval behavior is the same for yellow jackets and hornets. All are females. Other than their white color, these vespid pupae look like adults. They develop adult systems, then shed their pupal skins and chew through their silk cell cap. These newly emerged adult paper wasps pump out their wings and take their place as worker assistants to their mother. (Paper wasp queens and workers are the same size. Yellow jacket and hornet queens are larger than their daughters.)
Figure 14.2 Paper wasp nest (Image courtesy of Artist Unknown) Paper Wasp Nest Construction

From spring on, the queen lays eggs and the daughter workers feed larvae and expand the comb or nest. They do not eat the protein (insect) food they gather for the larvae but get their energy from flower nectar. Later in the season, some of the larvae develop into males and others will become next year’s queens.

The new males and females mate with those of other colonies and the fertilized females find hiding places under tree bark or in logs and wait out the winter until they can begin their new colony in the spring.

The male vespids die in winter. Likewise the old nest disintegrates and will not be used again.

CONTROL AND MANAGEMENT OF PAPER WASPS

- Paper wasp nests are often found near doorways and other human activity areas without occupants being stung. When paper wasps do become a problem, they can be controlled easily.
- When attracted to fallen ripe fruit, some wasps sting people who venture into the same area. Colonies in trees, hollow fence posts and other protected places are not as easy to control as those on structures.
- Remove old nests and scrape the point of attachment. New queens often select the point of attachment as a site for a new comb.
- Remove ripe fallen fruit as often as possible.
- Caulk openings in attics, window frames and around wall penetrations to keep overwintering females out of unused rooms and spaces.
- Use pressurized sprays that propel spray for 8 to 12 feet or use aerosols on extension poles especially manufactured for aerosol cans.
- For hanging suspended clearly visible nests wear a protective suit and veil; proceed cautiously especially if a ladder is needed.

BALDFACED HORNETS
(Dolichovespula maculate)

Figure 14.3 Baldfaced hornet (Image courtesy of Jerry A. Payne, USDA Ag Research Service, Bugwood.org)

Description - Baldfaced hornets are large black-and-white yellowjackets. The hornet gets its common name of baldfaced from the largely black color but mostly white face. The baldface hornet is of large size and has an aerial bag nest.

Adult workers are about 5/8 to 7/8 inch long. The queens measure ¾ to 1 1/8 inch long. They are colored black with a white pattern on most of the face, white stripes on the thorax and white bands on the last 3 abdominal segments. Baldfaced hornets build grayish paper nests shaped like an inverted pear and attached to branches or a recessed sheltered surface on a building.

Similar wasps (1) Yellowjackets (Vespula species) have yellow and black alternating markings on all abdominal segments. (2) The European hornet (Vespacrabo) has yellow, rust and brown body markings.

Baldfaced hornets are social insects which live in aerial nests. They attach their nests to low shrubs, high trees or high buildings. Aerial colonies can have 400 to 700 workers at one time. Their food gathering habits usually do not bring them into contact with humans. Often nests located in vegetation are not discovered until the leaves fall in the autumn. Nests are not reused the next season. Workers (sterile females), queens, and males (which develop from unfertilized eggs and appear in late summer) represent the adults. Only inseminated females overwinter in sheltered places.

Life cycle - In the spring, the queens develop a small comb with cells. Then she encloses the comb in a round, gray, paper envelope. One egg is laid in each cell as it is constructed. The queen feeds the developing larvae chewed-up insects, spiders and nectar. After about 30 days, the first 5 to 7 workers emerge and shortly take over all the work except laying eggs.

Baldfaced hornets gather flies for larval food. They are also large enough to kill and use other species of yellow jackets as larval food as well.
In late September, the nests consist of 3 to 5 disk-like paper combs attached one below another and encased in a multi-layered envelope. Nest size varies and contains 100 to 400 workers at its peak. Later in the season, larger reproductive cells are built in which queens and males are reared. Males are often reared in old worker cells. The colony is then entering the declining phase. The newly emerged queens and males leave the nest and mate. Only inseminated queens hibernate and survive the winter. The founding queen, the workers, and the males all die.

CONTROL AND MANAGEMENT OF BALDFACE HORNETS

- Remove old nests and scrape the point of attachment
- Caulk opening in attics, window frames and around wall penetrations to keep overwintering females out of unused rooms and spaces
- Use pressurized sprays that propel spray 8 to 12 feet or use aerosols on extension poles especially manufactured for aerosol cans
- For hanging suspended clearly visible nests wear a protective suit and veil; proceed cautiously especially if a ladder is needed
- Dust

GERMAN YELLOWJACKETS
(Vespula germanica)

The German yellowjacket is Ohio’s most abundant yellowjacket. The nests are constructed in attics, above eves, in soffits, false ceilings, and in deep box sills of bay windows and cantilever construction. The German yellow jacket may nest below ground as well as in old chipmunk and rodent holes.

Description – Yellow jackets are social insects and live in colonies. The adults are represented by workers which are sterile females, queens (fertile females), and males which come from unfertilized eggs. The males usually appear in the late summer.

Life cycle - Typically, only inseminated queens overwinter and do so in sheltered places. In the spring, they use chewed-up cellulose material to build up a paper carton or bag nest of a few cells.

One egg is laid in each cell and the queen feeds the developing larvae chewed up insects, spiders and nectar. After about 30 days, the first 5 to 7 workers emerge and shortly thereafter take over all the work except for laying eggs. The nest will eventually consist of a number of layered paper combs covered with a multi-layered paper envelope. Nest size varies from 300 to 120,000 cells averaging 2,000 to 6,000 cells that contain 1,000 to 4,000 workers at its peak. Later in the season, larger reproductive cells are built where queens will be raised. The males are usually raised in old worker cells. The colony is then entering the declining phase. The newly emerged queens and males leave the nest and mate.

CONTROL AND MANAGEMENT OF GERMAN YELLOWJACKETS

Problems with yellowjackets occur mainly when:

- A colony has infested a wall void, ceiling, or attic and has either chewed through the wall or ceiling into the house or the entrance hole is located in a place that threatens occupants as they enter or leave the building
- Worker yellowjackets are no longer driven to feed larvae in the late summer months and they wander searching for nectar and juices finding ripe fallen backyard fruit and beer, soft drinks and sweets at picnics, weddings, recreation areas, sporting events, and other human gatherings

Yellowjackets are sometimes responsible for injections of anaerobic bacteria (organisms that cause blood poisoning). When yellowjackets frequent wet manure and sewage, they pick up the bacteria on their abdomens and stingers. The stinger becomes a hypodermic needle. A contaminated stinger can inject the bacteria beneath the victim’s skin. Blood poisoning should be kept in mind when yellowjacket stings occur.

- Clean garbage cans regularly and fit them with tight lids
- Empty cans and dumpsters daily prior to periods of heavy human traffic at zoos, amusement parks, fairs, and sporting events
- Remove attractive refuse, such as bakery sweets, soft drink cans, and candy wrappers, several times a day during periods of wasp and yellow jacket activity
- Locate food facilities at late summer activities so that yellow jackets are not lured to dense crowds and events. The national park service IPM programs found that serving drinks in cups with lids dramatically reduced stings
- Clean drink-dispensing machines; screen food-dispensing stations, and locate trash cans away from food-dispensing windows
- To limit yellow jacket infestations in wall voids and attics, keep holes and entry spaces in siding caulked. Screen ventilation openings
- When possible, treat ground and aerial nests after dark when workers are in the nest. More often because of traditional work schedules, pesticide applications will be scheduled for the daytime when pests are active.
- Wear protective bee suits. These insects cannot get leverage to sting with this type of protective clothing
- Move slowly, quick movements will be met with aggressive behavior
- Approach the entrance hole cautiously; stay out of the normal flight pattern.
- Watch first. Observe whether yellowjackets entering the nest go straight in or to one side or the other.

**EUROPEAN OR BROWN HORNETS**  
*Vespa Crabro*

The European or brown hornet commonly known simply as the “hornet” is the largest European eusocial wasp. Its name is not to be confused with the baldfaced hornet and yellow jackets.

**Description** - The queen measures 1 to 1.4 inches long. Males and workers are smaller. Males have 13 segments of their antennae while females only have 12. The male abdomen has seven visible segments, while the female has six. Females have an ovipositor modified into a sting that is not barbed.

**Figure 14.6 European or brown hornet (Image courtesy of Gerry Wegner – Varment Guard)**

This species is not particularly aggressive except when defending the nest. Care must be taken when it is near because the stings are very painful. Like most stinging insects, European hornets will sting in selfdefense when grabbed or stepped on.

**Figure 14.7 European Hornet Nest (Image courtesy of Wikipedia)**

**Life cycle** - Hornets build their nests in protected areas such as hollow trees, hollow posts, partitions in sheds, barns, porches, and attics. Mature nests generally consist of 6-8 horizontal combs without the papery covering associated with many other hornets’ nests. Nests can be very large up to 2-3 feet in length, 20 inches in diameter and may contain 800-1,000 workers. Nests are annual and die out in the winter.

**ORGAN PIPE MUD DAUBERS**  
*Trypoxylon politum*

**Description** - The organ pipe mud daubers are large shiny black wasps with pale hind tarsi. Male organ pipe mud daubers are among the few male wasps of any species to stay at the nest. A male “stands guard” to prevent theft of nest materials and ward off parasites as well. Females are usually out collecting spiders that are food for the larvae. Mating typically occurs on her visits to the nest. They typically build their nests in sheltered locations, and large aggregations may form with dozens to hundreds of nests in a small area.

**Figure 14.8 Organ Pipe Mud dauber (Image courtesy of BugGuide.net)**

Organ pipe mud daubers are also a docile species of wasp and generally pleasant to have around because they keep...
spider populations down. Stings to humans are very rare bordering on non-existent, although if squeezed, they will sting in self defense.

**BLACK AND YELLOW MUD DAUBERS**

*(Sceliphron caementarium)*

Black and yellow mud daubers are solitary insects that build nests out of mud in sheltered locations, frequently on manufactured structures. These nests are not aggressively defended and stings to humans are rare.

The black and yellow mud daubers nest is comprised of a series of cylindrical cells that are plastered over to form a smooth nest that may attain nearly the size of a human fist. After building a cell, the female wasp captures several spiders. The captured prey are stung and paralyzed before being placed in the nest. Then a single egg is deposited on the prey within each cell. The wasp then seals the cell with mud. After finishing a series of cells, she leaves and does not return. Eventually, the hatching larva will eat the prey and emerge from the nest.

**CONTROL AND MANAGEMENT OF MUD DAUBERS**

Mud dauber nests can simply be scraped off with a scraper or putty knife then fragments can be swept from paved surfaces below. Future activity can be discouraged in a given area by the application of a residual pesticide.

**HONEYBEES**

*(Apis mellitiera)*

**Description** - Honeybees were introduced into the United States in colonial times. Honeybees are highly social insects and communicate with one another. They communicate direction and distance of nectar and pollen sources. Bees make combs of waxen cells placed side by side that provide spaces to raise young and store honey. The bee colony lives on the stored honey throughout winter and can persist for years.

When colony populations are high, the queen may move part of the colony to new harborage. Bees swarm at this time usually finding hollow trees to begin their new colony. They sometimes work their way into building wall voids.

**CONTROL AND MANAGEMENT OF HONEY BEES**

When you find a bee colony in a building wall, it must be killed. Killing can be accomplished in the same way as killing yellow jackets in wall voids. Listen to the bee noise from inside rooms to locate the exact position of the nests. Make sure the whole colony is treated for total control.

After the colony is dead, you must remove the nest. If you do not remove the nest, the wax combs will melt and allow honey to flow down through the walls. You can never remove a honey stain. You will have to replace the walls. The flowing honey attracts robber bees and wasps. The comb wax will attract flies, ants, and moths that may persist for several years. The dead bees attract dermestid beetles.

After the colony is killed and the nest removed, the entrance hole should be caulked or repaired to prevent further bee infestation.
LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Describe the habitat and life cycles of common types of “pest” spiders
- Understand pest management procedures for spider problems
- Describe the appearance or characteristics of harmful spiders

There are 3,000 kinds of spiders in the United States. They are categorized in the order Araneae. Like their arachnid relatives the mites, spiders live in all parts of the world. Spiders are valuable for their role as predators and natural regulators of insect populations. Some spiders when found in or around structures, are considered pests especially the poisonous ones. Fear of spiders prompts many people to insist on their control even if the spider represents no significant threat or problem.

The two-part spider shape is well known. Its head and thorax are combined to make the cephalothorax. Four legs are attached to each side of the cephalothorax. Spider eyes are in front. Some eyes are very large. Spiders do not have antennae.

Though all spiders are poisonous to some extent, few bite humans. Spiders mouthparts locate below the eyes have two short needle-tipped appendages called chelicerae (fangs). The central fangs are connected internally to poison sacs. The spiders use these fangs to bite prey. They prey mostly on other arthropods and inject them, which makes them immobile. Two short leg-like mouthparts help hold the immobilized prey while the chelicerae tear the exoskeleton. As blood comes out, it is sucked into the mouth cavity and ingested. Spiders keep working on their prey in this way until all the juices are gone and the prey is a dry, crumbled lump.

The abdomen is located behind the cephalothorax. It is saclike and usually globular. The anal opening is located near the end of the abdomen and close to short appendages called the spinnerets. Spiders produce silk webbing from these spinnerets.

All spiders produce silk and they use silk in more interesting ways than other silk producers do. Some spiders make silk retreats like tubes and funnels. Others make irregular cobwebs or webs like the great orb webs. Most spiders send out a dragline whenever they walk and never fall off edges without catching themselves.

Spiders do not have wings but they fly by releasing a thread of silk until it is long enough for the wind to catch it and carry them off. Ballooning is the name of the process where spiders fly. Newly hatched spiderlings use this method to leave the hatching area.

Two spiders are considered dangerous to humans in the United States: the black widow and the brown recluse. In reality, these two names each represent several species.

BLACK WIDOW SPIDERS (Latrodectus mactans)
The black widow spider is distributed over the eastern and southern United States. Travelers from other states introduced this species to Ohio. The native Ohio species is the northern widow (L. various).

Description - Female black widows have large, round, shiny black abdomens with two touching red triangles on the belly the (so-called “hourglass”). The native northern widow is similar except the hourglass is yellow to white rather than red. Black widows hang upside down in the web and the red hourglass is obvious. Sometimes dull red dots appear on the back and occasionally the triangles do
not touch this but this 1/2 inch or larger shiny black spider is unmistakable and eye-catching. Male black widows are small, white and streaked with yellow and red. They are not dangerous.

![Figure 15.1 Black Widow Spider (Image Courtesy of Clemson Extension, Bugwood.org)](image)

Black widow females are not aggressive but will give full attention to anything that disturbs the web. They weave tangled webs of coarse silk in dark quiet locations. Mature females are so large they can hardly crawl. Though pest management applications are not commonly called on for black widow spider control, they may run into these spiders in crawl spaces, porches, garages, and sheds for other pests. Black widow spiders can be found in stacked post of baskets, firewood, piles, rodent burrows, water meters, stacked boards, under bricks and stones. Usually the spiders are outside but they may be brought inside or the young may move inside on ground floors. Northern widows are common around pine stumps. Move cautiously when treating any potential spider harborage.

Black widow bites are immediately painful. The pain at the site of the bite increases during the first half-hour following a bite. Two small red marks from the fangs will be noticeable on the skin. After the first half-hour, other symptoms set in like headache, dizziness, shortness of breath, abdominal and back pain. Death seldom results from black widow bites to healthy adults. However, children and elderly persons are somewhat more vulnerable. Victims should receive hospital treatment as soon as possible.

**CONTROL AND MANAGEMENT OF BLACK WIDOW SPIDERS**
- Eliminate harborage sites carefully
- Pesticides must come directly into contact with the spiders because they do not leave their webs or wander after they have become established in the summer.
- A control method found in nature is provided by mud dauber wasps. They paralyze spiders and store them in their mud cells for their larvae to devour.

**BROWN RECLUSE SPIDERS**
*Loxosceles reclusa*

![Figure 15.2 (Image courtesy of Florida Department of Agriculture and Consumer Services, Bugwood.org)](image)

**Description** - The brown recluse spider is a dusky tan or brown with the widest range of any recluse spider in the United States. This spider is common throughout the Midwest, Eastern and Southern. Other species of recluse spiders live in the southwest, particularly in desert areas. The spider lives outdoors in the southern part of its range and primarily indoors throughout the rest of its range. The brown recluse spider is smaller than the black widow spider. It has an oval abdomen rather than a round one. The abdomen is uniformly tan to brown without marking. A dark fiddle shaped mark is obvious on the cephalothorax. The broad base of the fiddle begins at the eyes and the narrow fiddle neck ends just above the attachment of the abdomen. Legs are long with the second pair longer than the first. The brown recluse makes a fine irregular web. It commonly wanders in the evening in indoor infestations.

**Bites** – Recluse spiders avoid parts of rooms where human activity is prevalent remaining where there is no activity or unused rooms. Even though indoor infestations can be large, household inhabitants are seldom bitten. Bites can be expected when guestrooms are suddenly put into use or when stored clothing is brought out for use. Brown recluse bites are sharp but not initially painful like those of the black widow. They raise a blister very quickly. The blister when broken is usually surrounded by a red welt. The depressed center of this raised red circle (the size of a dime to a quarter) turns dark within a day. The dead tissue regularly sloughs away and the bite area scars over in one to eight weeks. Death seldom occurs but the bite is debilitating and mentally emotional.
The spider is delicate. After biting, it frequently can be found lying where the victim slapped it. It should be killed and taken to the doctor along with the victim for positive identification.

CONTROL AND MANAGEMENT OF THE BROWN RECLUSE SPIDERS

- Recluse spiders should be sought near places where bites occur.
- Look along walls in uninhabited rooms, under and behind furniture, in the far reaches of storerooms, in unused closets, under stairs, and in hanging clothing that has not been used during the current season.
- Concentrate on areas outside daily human traffic patterns. Homes and buildings that have been unoccupied for months or longer are particularly susceptible to increased spider populations.
- Recommend careful mopping or dusting of seldom-used rooms and closets.
- Inspect winter clothing that has hung in hallways or unused closets through the spring and summer. Store clothing in plastic bags.
- In the evening, reinspect spaces disturbed by dusting and mopping.
- Residual pesticides labeled for spiders should be used carefully to control the brown recluse spider.
- Apply the pesticide in all cracks and crevices particularly in spaces outside daily human traffic patterns.
- Spot treatments will be less effective than crack and crevice treatments because spiders touch spot residues only with hairs at the tips of their legs.

YELLOW SAC SPIDERS

*Chirocanthium mildei*

**Description** - The yellow sac spider introduced into the United States in the late 1940s is now a common insect. The native species is common outdoors. These spiders are about ¼ inch long with legs and cephalothorax darker than the abdomen. It has been reported being yellow, white, or greenish in color.

In late summer and early fall, yellow sac spiders migrate into structures and automobiles. At this time, they have not reached the adult stage. They weave protective white silken cocoon-like webs in which to overwinter and molt into adults in the spring.

The yellow house spider will bite if pressed or accidentally confined (e.g., during the victim’s sleep). The victims describe the spider bite as causing them pain and reddening of the skin at the site in some cases. In some instances, a deadening of the skin will occur but it is much less severe than that caused by the brown recluse spider. The yellow sac spider may have bitten children that show symptoms of spider bites (the two fang marks). However, this spider cannot pierce the skin of everyone. There is a very large margin of safety.

CONTROL AND MANAGEMENT OF YELLOW SAC SPIDERS

- Inspect rooms, particularly bedrooms, of suspected yellow house spider bite victims. Inspect obvious webbing sites in the fall as part of on-going monitoring activities for other pests.
- Look at the angles of the wall and ceiling door, window facings in furniture joints in larger cracks and crevices, in thermostats, and in other protected places.
- Look for webs inside jets and burner trains of gas appliances that are inactive during the summer-winter transaction period. Other sites are gas stoves in recreational vehicles, gas air conditioners and through-the wall gas furnaces. The silken obstruction interferes with gas flow operation. Failure can be an indication of their presence.
- Close gaps around outside entry doors and ground floor windows that may be entry points for spiders.
- Keep grass low next to building foundations to discourage wandering spiders.
Where biting is a problem, apply a residual pesticide labeled for spiders in cracks and crevices including closets and furniture joints. Apply pesticides carefully in small amounts and at low pressure to suppress drift and noxious odors. Ventilate the rooms after treatment.

WOLF SPIDERS
(*Lycosidae*)

**Figure 15.5 (Image courtesy of University of Nebraska Department of Entomology)**

**Description** – The wolf spider’s (family *Lycosidae*) body size ranges from 1.4 to 1.5 inches long. The leg span may be from 1 to 3 inches among Ohio species. Both body and legs have a hairy appearance. The coloration could vary from yellowish-brown, darker brown, and solid brown. The markings could be white or grey. There are a number of wolf spider species that live in the United States.

The eight eyes are arranged so the top middle pair is much larger than the other four. Wolf spiders have fair vision and are active hunters. Wolf spiders are mostly nocturnal and rest under logs, among leaf litter, in burrows or crevices during the day.

**Life cycle** - Females are slightly larger than males and are very maternal. These female wolf spiders typically lay 100 to 135 (up to 600) eggs in June and July. She wraps the eggs in a sac (1/2 inch across). The female carries her egg sack attached to her spinnerets until the eggs hatch. They carry their newly hatched spiderlings on their body until they can fend for themselves.

The juvenile wolf spiders spend the winter about half-grown in protected sites then complete development the next year. Adult males mate with females and die before winter. Adult females may live up to 3 years.

Wolf spiders are commonly found at ground level, in basements and garages of homes and buildings located in wooded areas, and newly constructed homes where farmland is just developed.

Wolf spider bites are rare but painful (bee-sting-like) because of the size of the jaws. The venom is mild and does not pose a threat to humans unless allergic reactions or secondary bacterial infections develop.

**CONTROL AND MANAGEMENT OF WOLF SPIDERS**

If called on to eliminate wolf spiders, the best action is to locate specimens, identify them and assure clients that they are not poisonous. Inform clients how they got inside.

- Close up gaps under doors and around window screens.
- Caulk door and window frames
- Remove vegetation and litter from the foundation doorway and window wells.
- Turn off house building or area light that attract flying insects (especially midges).
- Advise clients to look carefully at flowers brought in from the garden and from commercial greenhouses
- Assure clients that they can swat or vacuum spiders.

Pesticide application is very difficult. Indoor treatment is usually effective only if the pesticide contacts the spider directly. This means the application must have clear access to all spider habitats. Unless everyone performs efforts to exclude spiders (e.g., tighten gaps and observe material brought in) they will reenter.
LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Identify miscellaneous structural invaders
- Describe the life cycles, habits, and habitats of miscellaneous invaders
- Discuss pest management procedures for common miscellaneous invaders

HOUSE CENTIPEDES

*(Scutigera coleoptera)*

The centipede that lives indoors is known as the **house centipede**. Adults are over 1 inch long and run gracefully on 15 pairs of very long legs. House centipedes are found in small numbers in basements and other rooms not occupied. They feed on tiny insects and spiders. Although beneficial, often they frighten people, who then insist they be controlled.

MILLIPEDES

Millipedes are cylindrical with multiple segments. Millipedes have two pairs of legs attached to each segment as well as short antennae. Millipedes live outside in leaf litter and damp rotting wood. Unlike centipedes, they may build up in very large numbers. Millipedes migrate in dry weather and enter basements, ground floors, and window wells. They are a particular problem in houses located near woodlands. One species, the brown millipede, has been known to crawl up forest cabin walls when populations are numerous.

MANAGEMENT AND CONTROL OF HOUSE CENTIPEDES AND MILLIPEDES

- Remove leaf litter and compost near house foundations
- Caulk around door and window facings
- Weather strip doors and ground-level windows
- Apply residual pesticides to cracks and crevices around house foundations
- If the infestation is particularly persistent or if the migrating pests have built up in very high numbers, apply a band of residual pesticide around the house foundation as a barrier.

CRICKETS

**Family Gryllidae**

Crickets are well known relatives of grasshoppers and katydids. Like katydids, male crickets “sing” in the summer by moving hard parts of their wings together to call females for mating. They develop with gradual
metamorphosis. During some periods, adults and nymphs share the same harborage and food with grasshoppers.

**HOUSE CRICKETS**  
(*Acheta domesticus*)

House cricket adults are about 3/4 to 7/8 inch long and are light yellowish-brown (straw-colored). They have three dark bands on their head and have long, slender antennae much longer than the body. Their wings lay flat on the back but are bent down abruptly on the sides. Females have a long slender tube-like structure (ovipositor) used for egg laying projecting from their abdomen. Both males and females have two antenna-like (cerci) sensory organs attached to the sides at the tip of the abdomen.

House crickets normally live outdoors (especially in garbage dumps). They prefer warm weather but will move indoors when it gets colder in late summer. Overwintering occurs outdoors in the egg stage. Each female can lay many eggs. The nymphs resemble the adults, but they do not have wings. Nymphs molt seven to eight times and reach adulthood in about 60 days. In addition, these crickets can live indoors, completing their life cycle with eggs laid in cracks, crevices, and other dark areas such as behind baseboards.

Adults are very attracted to lights and become active at night. They hide during the day to crawl, jump or fly sometimes in countless numbers up the sides of houses and enter openings. They can enter openings of second and third story windows and roof skylights. The continued monotonous “chirp” is loud and distracting, which results in lost sleep. They will feed on silk, woolens, nylon, rayon, and wood. They can bite when handled carelessly. They are found in fields, pastures, lawns, roadsides, and in woods.

**CAMEL CRICKETS**  
(*Ceuthophilus* sp.)

Adults are a little over 3/4 inch long. They are light tan to dark brown with darker bands on some segments. The camel cricket is wingless with its head bent downward; its back is arched (humpbacked appearance) with large hind legs and long antennae.

Camel crickets are active at night in cool, damp, dark areas and occasionally invade damp basements or crawlspaces. They are not attracted to lights or produce songs. Their appearance is alarming to some people. Camel crickets damage some textiles. They hide under hay bales and feed on other insects seeking shelter there. Most camel crickets usually live in caves, hollow trees, under logs and stones, and in other dark, moist places. They can also live and reproduce indoors, such as in greenhouses, potting sheds, outbuildings.

**CONTROL AND MANAGEMENT OF CRICKETS**

- Locate the egg-laying sites where populations build up if possible
- Look near patches of weeds, soil, cracks, at the bases of plants, or in grass
- Inspect basements, closets, pantries
- Caulk, tighten, and weather strip basement and ground-floor doors and windows to keep crickets out of houses
- Thin plantings next to building foundations
- Ventilate and remove materials that provide hiding places in crawl spaces and garages
- Direct pesticide spray application into cracks near the foundation and around door stoops and patios
- Apply a residual barrier around the building if populations are very high
- Use granular baits when needed
- Where very high buildup is detected in breeding areas, particularly in a series of cricket invasion years, spray the weeds and grass in midsummer with pesticides labeled for cricket control on plants.
- Advise clients to place sticky traps for control of field and camel crickets indoors or spray them with a general-use contact aerosol or liquid.
- Some insecticide dusts are labeled for use against camel crickets in crawl spaces and garages but are seldom needed.
SOWBUGS (Armadillidium spp.) AND PILLBUGS (Porcellio ssp.)
Class Crustacea
These small, oval land crustaceans, protected by objects on the ground, feed on decaying and live vegetable matter and fungi. They have been known to clip outside plant roots, but very little damage is expected of them. Heavy infestations outside encourage movement that causes individuals to find their way inside.

Sowbugs and pillbugs live outdoors but they may occasionally enter homes in damp areas such as basements, first floor levels, and garages. These creatures are a nuisance by their presence. They do not bite humans, damage structures or household possessions. If large numbers are present, they can feed on young plants in greenhouses. Some crawl into swimming pools and drown causing complaints. The ones that wander into homes usually die in a few days unless they find a moist place.

Figure 16.5 Sowbug with young (Image courtesy of the University of Kentucky – Entomology)

Sowbugs are oval or slightly elongated with a flattened body and up to 3/4 inch long. They are wingless and brownish or slate gray. They possess well-developed eyes, seven pairs of legs and overlapping “armored” plates that make them look like little armadillos. Sowbugs have two tail-like structures on the rear end. Pillbugs are similar, except they lack the tail-like appendages and can roll up into a tight ball. Both are slow moving and are related to crayfish shrimps and lobster, but not insects. The young resemble the adults but they are smaller and lighter in color.

Figure 16.6 Pillbug (Images courtesy of Joseph Berger, Bugwood.org).

Both sowbugs and pillbugs mate throughout the year with most activity in the spring. The female carries the eggs, which number from 7 to 200, in a brood pouch under her body. Eggs hatch in three to seven weeks, and the young are white-colored. They remain in the brood pouch for six to eight weeks until they are able to take care of themselves. There may be one to two generations per year. Individuals live up to three years depending on weather conditions.

These creatures live outdoors feeding on decaying organic matter and occasionally young plants and their roots. They may become pests in and around homes where flowerbed mulches, grass clippings, leaf litter, rotting boards, trash, rocks and pet droppings are present. Adequate moisture is essential for their survival and they group in masses to reduce water loss. On a hot day, they remain under objects on the damp ground and are active only at night due to lower temperatures and conditions that are more humid. They become inactive during the winter months except in heated buildings such as greenhouses.

- Remove places where sowbugs and pillbugs can develop near the house such as boards on the ground, flower posts and flat stones
- Remove mulch and replace with gravel if necessary
- If inside, use a vacuum

EARWIGS (Forficula auricularia)

The name earwig comes from a European superstition that these insects enter the ears of sleeping people and bore into the brain. Earwigs, when discovered indoors, cause alarm to some homeowners. They have a frightful appearance and move rapidly around baseboards on lower levels. They also emit a foul-smelling yellowish-brown liquid from their scent glands. These creatures are active at night and hide during the day. They are harmless to humans but if handled carelessly earwigs can give a slight pinch with its forceps. Serious feeding on flowers, vegetables, fruits and other plants damage leaves with small irregular holes. They consume decomposing organic matter as well. Earwigs are temporary pests, even though they sometimes occur in large populations.

Earwigs are long flattened insects. They range from light red-brown to black and are easily recognized by their forceps-like pincers at the end of their abdomen. The
forceps are not equal in length on the males. Earwig female forceps are straight-sided. The males’ forceps are strongly curved (caliper-like) and larger. Earwigs have chewing mouthparts, long slender antennae and may be either winged or wingless. Adults of the European earwig (figure 16.7) are winged and are common in the Midwest. If wings are present, the first pair is hard, short and beetle-like. The second pair has a membranous fan-shape and is folded under the hard first pair of wings. Tips of the second pair of wings usually stick out from under the first pair. The earwig is 1/2 to 3/4 inch long. Earwig nymphs are similar to adults. They are white to olive-green and lack wings.

Earwigs develop from egg to adult through gradual metamorphosis with four or five nymphal stages. During the spring or autumn females lay 20 to 50 smooth, oval, pearly-white or cream-colored eggs in a below ground chamber. The female moves, cleans and provides maternal care and protection for the eggs. She also cares and protects the new young until the first molt. The young then leave the nest, fend for themselves and mature in one season. Both eggs and adults overwinter. Earwigs may dig or follow crevices as deep as six feet below ground to escape cold temperatures. They are active at night and are often found around lights. During the day, they hide in moist, shady places beneath stones, boards, sidewalks, and debris. They are rapid runners and feed on mosses, lichens, algae, fungi, insects, spiders, and mites, (both dead and alive). Some earwigs are predators, feeding on aphids, and others feed on living plants becoming pests in greenhouses and on certain crops like vegetables, fruits, ornamentals, forages and field plants.

CONTROL AND MANAGEMENT OF EARWIGS

- Look under bark, boards, and stones near house foundations
- Inspect cracks around foundations and door stoops
- Check behind birdhouses, under tree trunk wrappings, and under plant mulch
- Caulk ground baseboard entries, windows, and cracks between door stoops and thresholds
- Remove as much harborage as possible
- Trim hedges and plants away from foundations
- Ventilate and dehumidify moist basements, porches, and so forth. Lowering the humidity or moisture discourages earwig build up
- Prepare a band of low-mowed grass on which residual pesticide sprays or granules can be applied when earwig infestations are very high
- Spray in cracks next to the foundation and under shrubbery
- Sprays of detergents are known to kill earwigs.

CLOVER MITES

*Bryobia praetiosa*

This fast moving harmless mite has a body less than 1/16 inch long in its adult stage. It is bright to dark red and when smashed it leaves a red streak. The clover mites’ front legs are as long as its body or twice as long as the other legs and they move like antennae. This characteristic sets them apart from other red species.

There are no male clover mites in the Unites States. Females deposit their red eggs in structural crevices and building cracks from early summer to late fall. Eggs laid in the fall hatch the following spring.

Nymphs develop from spring and summer eggs to invade dwellings in the fall.

Their habitat is grass and low weeds near building foundations warmed by the sun and sheltered from cold. Mite invasions are influenced by the temperature in their habitat combined with heat reflected from adjacent buildings. Mites build up on the south side of buildings where habitat temperatures reach above 69°F on sunny days, and when air temperatures are much lower. As general air temperatures increase, temperatures in mites’ habitats increase. Both egg and mite development and activity suspend when temperatures exceed 75°F or below 45°F in their ground level habitat on grass or house foundations and siding.

When active, mites move from the grass to foundations under sheathing, into wall cracks and spaces, and around windows. This leads them indoors. Mites that reach interior wall voids in the fall may contribute to the following early spring invasion. Clover mite populations seem to be highest and most invasive following the installation of new lawns. Clover mite populations reach their height where subdivisions or housing developments are landscaped by seeding or raking bare earth. Fertilized grass contributes to mites’ well being. Lack of shade allows uniform temperatures across the sunny lawns. Scraped bare soil is devoid of predatory mites and insects. It encourages the free buildup of clover mites on newly sodded lawns and fertilized grass. As the lawn matures and the plant, shrub, and tree community diversifies a varied insect population is supported and clover mite invasions cease.
CONTROL AND MANAGEMENT OF CLOVER MITES

Outside
- Cover bare earth gravel, or gravel over plastic, as a barrier strip. Make the strip about two feet wide on the sunny side of buildings to stop clover mite migrations.
- Plant shrubs in front of this strip. Shrub mulching will add to the barrier’s effectiveness by diversifying the habitat and breaking up the even temperature gradient near the foundation.
- Closely mow the lawn in a 20-foot band to decrease grass protection and temperature insulation.
- Caulk building cracks and spaces where window and door framing join building siding.

Inside
- Caulk windows, door framing, and weather strip windows on the sunny side of the house.
- Caulk electrical plates.

BOXELDER BUG 
(Boisea trivittatus) (Say)

Figure 16.9 (Image courtesy of William M. Ciesia, Forest Health Management Int. US, Bugwood.org)

During the warm days of autumn, boxelder bugs invade buildings seeking shelter for overwintering. These bugs are attracted to lights. They will eagerly fly through open doors and windows. Boxelder bugs are a nuisance indoors. When crushed they give off a foul odor and may stain fabrics with fecal matter. When outdoors they sometimes cluster in large numbers on sides of trees, buildings, and other structures. Long, hot, dry summers link boxelder bugs with larger populations. During warm winter and spring days, boxelder bugs move from their hiding places into living spaces.

Adult boxelder bugs are flat-backed, long and narrow. They are about 1/2 inch long and 1/3 inch wide. These bugs are brownish-black with three lengthwise red stripes on the area behind the head (the pronotum). The head is black with the “beak” or proboscis (tubular feeding or sucking organ) being reddish-orange. The long, thin, four-segmented antennae are half as long as the body. Wings are thick, leathery at the base, and membranous at the tip. There are red veins in the wings, and the abdomen is bright red under the wings. The nymphs resemble the adults in shape except they are smaller, more rounded, wingless, and bright red. Eggs are dark reddish-brown.

During autumn, adult and large nymph boxelder bugs gather in large numbers. They gather mostly on the bark of boxelder trees and then begin migrating to a place for overwintering. Only full-grown adults overwinter. They move to hibernation sites by either crawling or flying. They can crawl from a nearby tree or fly about two miles to find shelter. These bugs are hidden in cracks and crevices in walls, in door and window casings, around foundations, in stone piles, in tree holes, and in other protected sites. On warm days in the winter and early spring, they reappear sometimes on light-painted surfaces outdoors to rest in the sun.

Overwintering adults leave their hibernating quarters with the coming of spring and warm weather. Females usually begin laying eggs late April to early May. The females lay the eggs in crevices of tree bark, stones, leaves, grasses, and on other objects near host plants. Eggs hatch in 11 to 19 days with bright-red nymphs appearing about the same time that new tree leaves develop. There are five nymphal instars. The instars get progressively darker red with each stage. The new adults lay eggs in July that result in the second generation by autumn. Boxelder bugs feed mostly on the seed-bearing boxelder trees by sucking sap from the leaves, tender twigs, and developing seeds. Sometimes they have been seen feeding on ash, maple, plum, cherry, apple, peach, grapes and strawberries, causing some scarring on fruits.

CONTROL AND MANAGEMENT OF BOXELDER BUGS
- Plant staminate (male) boxelder trees
- Eliminate potential hiding places like piles of boards, rocks, leaves, grass, and other debris close to the house.
- Rake leaves and grass away from the foundation in a six to ten foot strip on the south and west sides of the structure
- Caulk and close openings where boxelder bugs can enter the house around light fixtures, doors and windows, unscreened vents, and holes in walls
- Caulk openings around utility pipes or conduits, air conditioners, heat pump lines and through foundations.
- Put screens on windows, doors, crawl spaces, exhaust and roof vents and louvers.

LEAFFOOTED BUG
(Leptoglossus occidentalis)
The most invasive leaffooted bug in the Midwest is the western conifer seed bug (figure 17.10). Adults are about 3/4 inch long with moderately heavy bodies (they resemble squash bugs). They are reddish, dull brown with a faint white zigzag straight line across the center of the wings. The hind legs are flattened (leaf–like tibiae) with
a white dot on the upper side. They have well developed scent glands with pleasant odors (like pine) and those that are not so pleasant.

**Figure 16.10 (Image courtesy of David Cappaert, MSU, Bugwood.org)**

The leaffooted bug can become a nuisance when crawling up the sides of buildings during autumn months. Sometime they gather in small groups of as little as 5 or as many as 100 on one house at a time. Bugs take flight and can make a buzzing noise if disturbed. Some overwinter in the house and emerge on warm sunny days during winter and spring.

Overwintering adults come out from hibernation in late April and early May. They fly to nearby conifers. The females lay clusters of yellowish-orange eggs on or near the seed cones of pine, Douglas fir, and incense cedar. These eggs hatch in about 2 weeks. The nymphs then start feeding by sucking nutrients from the cones. During the summer, nymphs go through 5 growth stages between molts. In Ohio, there is 1 generation per year.

Leaffooted bugs are good flyers. During warm weather, they are alert to approaching movement and will take flight quickly. They have well developed glands, which they use for defense. The secretions smell like ripe pear or green apple essence.

**CONTROL AND MANAGEMENT OF LEAFFOOTED BUGS**

- Use special yellow lights that are least attractive to these bugs
- Caulk and seal any openings that lead into dwellings around windows and doors.
- Check all roof, soffit and gable vents and attach insect screening over vent openings.
- Stuff weep holes with copper gauze or steel wool.
- Silicone sealer or builders putty should be applied around cable and utility penetrations. These steps should be taken before late August.
- Temporary but immediate indoor relief is achieved by using a vacuum to remove bugs.
- Trees and shrubs can be sprayed with labeled pesticides during summer.

**MULTICOLORED ASIAN LADY BEETLES (Harmonia axyridis (Pallas))**

Lady beetles are beneficial predators that eat aphids, scale insects, and many other pests that injure plants in our gardens and landscapes. This species is native to Asia where it is an important predator. While in their native habitat these lady beetles often hibernate (overwinter) in cracks and crevices on cliff faces. There are not many cliffs in the United States so they seek hibernation sites in the structural voids of buildings.

During the past decade, this lady beetle has become a seasonal pest in many regions of the country. It was in Ohio, during October 1993, when some residents reported that thousands of lady beetles were on homes and buildings. They were trying to find their way indoors.

The multicolored Asian lady beetle made its way to the United States through a number of accidental and planned releases. There are several reports that this species was accidentally brought on ships to various ports. This lady beetle was also intentionally imported from Russia, Japan, Korea and elsewhere in the Orient. They were imported as a federal effort to naturally control soybean aphids and related insects. The native species of lady beetles were not as effective.

During the late 1970s through the early 1980s, the U. S. Department of Agriculture’s Agriculture Research Service (USDA-ARS) intentionally released tens of thousands of multicolored Asian lady beetles in an effort to control insect pests that injure trees. The USDA-ARS coordinated the lady beetle releases in many southern and eastern states including Ohio. About 1,800 lady beetles were released in Cuyahoga and Lake Counties during June 1979 and July 1980. The program was discontinued because failed recapture efforts suggested that the multicolored Asian lady beetle was not surviving.

There is some controversy regarding the origins of this foreign species. The multicolored Asian lady beetle is now well established in the United States. This foreign species of lady beetle appears to be replacing some of our native lady beetles in Ohio.
Adult multicolored Asian lady beetles are about 0.2 to 0.3 inches long and have a black “M” marking on the white pronotum. They are typical of many other lady beetle species with a domed round to oval shape. The multicolored Asian lady beetles are sometimes confused with other types of lady beetles in outdoor situations. An important characteristic of the multicolored Asian lady beetle species is they will seek hibernation sites in or around buildings. While the native lady beetle species seek hibernation sites outdoors.

Larvae (immatures) are covered with tiny flexible spines (non-stinging). Their body is long and somewhat flattened. The young move rapidly through leaves and branches where they eat aphids and other soft-bodied insects. Eggs are yellow oval shaped and occur in clusters of about 20 usually on the undersides of leaves.

Large lady beetle populations build up during cool wet summers that favor tender foliage with large infestations of aphids. The life cycle from egg to adult is about a month or so depending on the weather. Eggs hatch in 3 to 5 days. Larvae feed for 12 to 14 days. Larvae eat large numbers of aphids, scale, and other soft-bodied insects during this time. Pupation lasts 5 to 6 days until adults emerge. The adult stage is the longest with some lady beetles living up to 2 or 3 years.

When the weather starts to turn colder in the fall, the lady beetle adults start to seek hibernation sites. The lady beetles appear to move toward light-colored objects like white buildings. Large numbers collect on outside walls warmed by the sun on the south and southwest sides. When one lady beetle lands, many others soon follow. Some research suggests that this behavior may involve chemical cues (pheromones), visual cues, or both. However, additional research is needed.

**CONTROL AND MANAGEMENT OF THE MULTICOLORED ASIAN LADY BEETLES**

- Seal cracks around windows, doors, siding, utility pipes, and other openings.
- Use weather stripping or a good quality silicone or silicone-latex caulk.
- Install tight-fitting door sweeps or thresholds at all exterior entry doors.
- Around garage doors, install a rubber seal rather than vinyl, which seals poorly in cold weather.
- Install insect screen over attic and exhaust vent to prevent lady beetle entry.
- Replace and repair damaged door and window screens.
- Preventive pesticide treatment of residual insecticide labeled for pests.
- Use a vacuum or shop vac for infestation inside dwellings.

### SPRINGTAILS
(Order Collembola)

Springtails sometimes cause alarm to homeowners when they see them outdoors or indoors in large numbers. They appear as “piles of soot” in driveways, backyards, and on mud puddle surfaces, etc. Occasionally they enter the home where dampness occurs like in basements, cellars, bathrooms, kitchens, and especially near leaking pipes and drains. Springtails usually appear in the spring and early summer but can be found year round. Some are known as “snow fleas,” appearing on the top of snow during late winter and early spring. These very small, leaping insects do not bite humans, spread disease, or damage household furnishings. They are usually a nuisance by their presence.

Springtails are minute wingless insects about 1/16 to 1/8 inch long. Colors vary from white, gray, yellow, orange, metallic, green, lavender to red. They get their name from the ability to catapult themselves (leap) through the air three to four inches by means of a tail-like mechanism (furcula) tucked under the abdomen. When disturbed this appendage functions as a spring propelling them into the air away from the danger source. Young resemble adults except for size and color. Eggs are spherical.

Springtails occur in nearly every climatic condition throughout the world. They are in high mountain regions, pools, streams, snow-covered fields, forest floors, etc. Springtails live in the soil, in leaf mold, under bark, in decaying logs, on the surface of freshwater pools, in organic mulches, in termite nests, in snow, in greenhouses, in mushroom cellars, etc. Populations are often high up to 1,000,000 per cubic meter of surface soil or many millions per acre. Most feed on algae, fungi, and decaying vegetable matter, and they are abundant only in damp, moist or very humid locations. Others feed on plant roots or nibble on young plant leaves and germinating seeds in hotbeds. Actually, they are beneficial by reducing decayed vegetation to soil. They are good recyclers. For example, they are among the few organisms known to break down DDT in the soil. Some can reproduce at
temperatures as low as 40° F. They move by crawling or jumping, which is followed by rest periods.

Sometimes they may become pests when they enter homes through doorways, screens or other openings. Buildings with constant high humidity may be overrun with springtails. Homeowners often notice springtails on windowsills and floors by baseboards.

**CONTROL AND MANAGEMENT OF SPRINGTAILS**

- Any means to provide a drying effect in the home is very effective for springtails. The use of fans, dehumidifiers, repairing plumbing leaks, etc. will help.
- Avoid over-watering potted houseplants and allow soil to dry between watering if possible.
- Outside the home, remove excessive mulch and moist leaves.
- Prune shrubbery and ground cover to eliminate low moist areas around the house foundation to promote proper air circulation.
- Remove wet moldy wood or other items.
- Since springtails are attracted to light and may pass under lighted doorways at night, use good light discipline.
- Household pressurized aerosol sprays contain pyrethrins or resmethrin, which will quickly reduce a troublesome population in the home on a temporary basis.
- Potted houseplants can be treated with a pesticide labeled for this use and pest.
- Outdoor residual spays can be used for springtail control.
LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Identify common wood destroying insects
- Describe the life cycles, habits, and habitats of wood destroying insects
- Discuss pest management procedures for common wood destroying insects

CARPENTER ANT
(Camponotus pennsylvanicus)

Description - The workers range in size from 1/4 inch to almost 1/2 inch. The queen is 3/4 inch. Outside workers can be confused with field ants (Formica) which usually do not enter structures. Carpenter ants have a smooth, arching profile on the upper surface of the thorax from the head to the waist, or petiole, which has one node. Field ants and most other ants have bumps or spines along the profile of the thorax, particularly near the petiole. The carpenter ant’s abdomen is covered with gray or yellowish hairs, but the basic black color still shows through. The head and thorax are black in the majority of individuals. Some carpenter ants’ sides of their thorax and part of their legs may be a dull red instead of black.

Life cycle - A carpenter ant colony begins in isolation but not necessarily in wood. This first brood may be under a stone, in a roll of tarpaper, or in many other places. The colony soon moves to wood like a fallen log, tree hole, stump, or structure wall. When carpenter ant workers excavate nest galleries, they use their jaws as gouges. They make tunnels by shaving out small pieces of wood. A carpenter ant parent colony requires high humidity and includes the queen, eggs, larvae (brood), pupae and adult offspring – workers and alates (winged reproductives). Satellite colonies do not include the queen or eggs. Unlike termites, they do not eat the wood. It has no nutritional value to them. They discard the wood by dropping it out of the nest area or by piling it in one place and dropping it out of the nest all at once. The pile of carpenter ant shavings, called frass or sawdust, is very soft. It is made up of pieces like those a fine chisel would make. Leftover gritty construction sawdust in attics or on sills from construction or repairs might suggest carpenter ant damage to those who do not know the difference. Carpenter ant frass also contains discarded pieces of dead carpenter ants and prey. Empty pupal cases may also be found in the frass.

The process of ant gallery excavation results in galleries with very smooth sides. No mud is involved like with termites, and there is no dust like with woodborers. There are large, smooth, brown-stained tunnels that provide shelter for the carpenter ant colony. A nest or colony might harbor several thousand inhabitants. Large colonies of carpenter ants...
in critical areas of structures can cause structural damage. The colony is more likely to reside partially in structural wood and partially in void spaces such as between roof boards, under windows, and under shower bases etc.

The most common outdoor harborage is a living tree with a rotted spot inside. Other common sites are stumps or damp firewood. The carpenter ant is a valuable link in the reductions of plant cellulose. It is not surprising that mature wooded neighborhoods have carpenter ant problems. New neighborhoods or developments built on cleared woodlots can inherit ant colonies from trees. Some colonies are in building materials. Rustic cabins, summer homes, and park structures will likely become infested.

Carpenter ant workers forage for food such as honeydew, insects, and juices from ripe fruit. When foraging indoors, they like sweets, meats, fruit juices, and moist kitchen refuse. Carpenter ants always prefer a humid atmosphere. Vines on building walls, branches, and telephone wires provide a bridge-like access into structures.

CONTROL AND MANAGEMENT OF CARPENTER ANTS INSPECTIONS

It is important to discover whether carpenter ants are inside or outside. If nesting inside:

- Their presence usually indicates a moisture problem in the building.
- They have excavated galleries for shelter in structural wood.

Moisture problems and carpenter ants are nearly inseparable. In the majority of cases, carpenter ants make their nests in wood that has been wet and infested by brown rot fungus. Dark fungus stains on the wood indicate the presence of such moisture. Moisture is caused by:

- Improper attachment of wooden additions, dormers, and hollow wooden columns that absorb moisture
- Patios or porch floors, door sills, downspouts, or grading where water collects or drains toward the structure
- Regular gutter overflow pouring rainwater down the side of the building, back onto the roof, fascia, and soffits, etc
- Leaking roof valleys
- Improper flashing around chimneys, vents, and skylights
- Improper roofing or holes in the roof
- Window sills directly exposed to rain
- Lack of ventilation in any area where moisture accumulates

Inside moisture accumulates:

- Around any leaking plumbing or drains
- Unvented attics and crawl spaces
- Unvented dishwashers, washing machines, clothes dryers, icemakers, etc

The many nesting sites, foraging entrances, and food and moisture sources offer clues for inspection and location of the nests. The area where the majority of ant activity is seen may identify a nest site if entry from the outside can be ruled out. Carpenter ants are more active at night, and inspection at that time of day may be helpful.

Where nests are located inside, remove and replace infested structural wood.

- Stop the intrusion of moisture.
- Caulk and screen actual and potential entry-ways.
- Ventilate areas where moisture accumulates, regrade where necessary, and repair roofing, guttering, etc.
- Recommend trimming trees where branches touch a structure or overhang roofs. Tree removal may be necessary.
- Inspect behind and under insulation in basements and attics.
Eliminating colonies and nesting sites is a primary way to eliminate carpenter ant infestations.

- With the use of flushing agents alone, hundreds of ants may remain unaffected and can relocate the colony. The colony can relocate in a matter of hours or less to trunks, storage boxes, furniture drawers, and other voids.
- When indirect treatment is required, use liberal placement of acceptable bait stations.
- You can use dusts, sprays, or baits on outside colonies (e.g., in tree rot).
- Professionals should evaluate trees with rotted places.
- Treat honeydew-producing insects involved in feeding carpenter ants with pesticides that will not eliminate parasites and predators.

Maintain records of all inspection discoveries and records mandated by law.

**CARPENTER BEE**

*(*Xylocopa virginica*)*

**Figure 17.4 (Image courtesy of University of Florida)**

**Figure 17.5 Carpenter Bee Damage of Wood (Image courtesy of PA Department of Conservation and Natural Resources – Forestry, Bugwood.org)**

**Description** - Carpenter bees are called this because they excavate galleries in wood to create nest sites. They do not eat wood. They feed on pollen and nectar. Carpenter bees are important pollinators of flowers and trees. Carpenter bees are usually nuisance pests that cause cosmetic instead of structural damage to wood. However, considerable wood damage can result from many generations of carpenter bees enlarging existing galleries in wood.

Carpenter bees resemble bumblebees, except bumblebees have dense yellow and black hairs on the abdomen and large pollen baskets on the hind legs, while carpenter bees have a nearly naked black abdomen. Various species of bumblebees and carpenter bees are similar in size. Bumblebees typically nest in the ground and carpenter bees nest in wood.

**Life cycle** - Carpenter bees are solitary insects that do not form colonies. Male and female carpenter bees overwinter as adults in their old nest gallery. Adults emerge in the spring (April and early May) and mate. There is one generation per year.

The males do not live long and the female carpenter bee prepares the nest. Gallery construction is a time and energy-consuming process. A female will refurbish an old nest rather than excavate a new one. When constructing a new nest the female uses her strong jaws to excavate a clean-cut round entrance hole on the lateral surface of the wood. The hole is slightly less than 1/2 inch wide, which is about the diameter of her body. She bores into the wood perpendicular to the grain for one to two inches then makes a right angle turn (~90°) and excavates along the wood grain for four to six inches or more to create a gallery (tunnel). She excavates the gallery at the rate of about one inch in six days.

The female bee creates a series of provisioned brood cells in the excavated gallery. The larval provision consists of a mixture of pollen and regurgitated nectar formed into a ball. The female forms a food ball at the far end of an excavated gallery. Then she lays an egg on top of the mass and walls off the brood cell with a plug of chewed wood pulp. A female often creates six to ten partitioned brood cells in a linear row in one gallery and she dies soon thereafter. Larvae feed on the pollen/nectar food mass, which is sufficient food for them to develop to the adult stage.

The life cycle (egg, larva, pupa, and adult) is completed in approximately seven weeks depending on temperature. The new adults typically remain in their gallery for several weeks then chew through the cell partitions and venture outside in late August. They collect and store pollen in the existing galleries and spend much of their time huddled together inside a gallery. These new adults hibernate in galleries because they require shelter during the winter. They emerge the following spring.

Carpenter bees nest in a wide range of soft woods and hardwoods especially if the wood is weathered. Eastern species of carpenter bees prefer softwoods such as cedar, redwood, cypress, pine, and fir. The
bees can more easily tunnel through woods that are soft and that have a straight grain.

Carpenter bees attack structural timbers and other wood products such as: fence posts, utility poles, firewood, arbors, lawn furniture and wooden swing sets. In buildings, carpenter bees nest in bare wood near roof eves and gables, fascia boards, porch ceilings, decks, railings, siding, shingles, shutters, and other weather wood. These bees avoid wood that is well painted or covered with bark.

CONTROL AND MANAGEMENT OF CARPENTER BEES
- Pesticide foams can be used inside entrance holes
- Pesticide dust formulations can be used with plugs
- Plug entrance holes to galleries with caulk, wood filler, or wooden dowels
- If possible fill entire gallery with a sealant

POWDERPOST BEETLES
Powderpost beetles are called this because larval feeding can reduce wood to a mass of powder. A thin shell of sound, perforated wood with small holes (Figure 17.6) surrounds the powder. This is when wood is heavily infested or repeatedly attacked over an extended period by beetles.

Description - Species in the beetle families Lyctidae, Anobiidae, and Bostrichidae are of concern in structures because they can breed and (reinfest) wood in use.

Lyctid beetles are reddish brown to black and 1/16 to 1/8 inch long. Their body is long and flattened. A key characteristic of lyctid beetles is the two-segmented antennal club. Unlike anobiids and bostrichids, they are visible from above. The adult exit holes measure 1/32 to 1/16 inch across. Ejected frass consists of fine yellowish white powder.

Anobiid beetles are reddish brown to brownish black and range in length from 1/8 to 3/16 inch. They have slender cylindrical bodies. In most species, the head is bent downward and concealed by a hood like pronotum. The antennae have 11 segments. The adult exit holes measure 1/16 to 1/8 inch across. Ejected frass is a combination of fine yellowish powder and small pellets.

Bostrichid beetles are reddish brown to dark brown or black and 1/32 to 3/8 inch long. They generally are cylindrical with a roughened thorax. The tips of the hard forewings (elytra) are frequently concave and pitted. The head is bent downward and is not visible when viewed from above. The antennal club has three or four segments.
Powderpost beetle larvae are grub-like. They have a C-shaped body that is enlarged at the thorax. They are yellowish white with a brown head. Because powderpost beetle larvae develop inside wood, they are usually not available for identification purposes. Species identification is difficult because many of the species of larvae are similar in appearance.

A key characteristic of lyctid beetle larvae is that the eighth (rear) abdominal spiracle (breathing system) is much larger than the others. All abdominal spiracles of anobiid and bostrichid larvae are the same size.

**Life cycle** – The life cycle length (egg to adult) for powderpost beetles depends on the nutrients in the wood, temperature, and humidity surrounding the wood. Larval development usually occurs quickly at 66-88°F and 80-90% relative humidity. Larval development occurs quickly in wood with high nutrient levels and moisture content greater than 12%. Wood moisture, nitrogen, or starch content are limiting factors.

![Powderpost beetle larvae](UDSA Forest Service Archive, USDA Forest Service, Bugwood.org)

The life cycle of lyctids is shorter than the other powderpost beetles. Lycids usually have only one generation per year. During favorable conditions, they may complete a life cycle in three months or less. During less favorable conditions, it may take three to four years to complete a life cycle. The length of the life cycle is typically one to five years for anobiids and one year for bostrichids.

Powderpost beetles only lay their eggs on bare unfinished wood, but the placement site varies depending on the beetle family. The female lycid inserts her eggs into the wood pores. Anobiid eggs are usually laid on the wood surface, in cracks and crevices, or in exit holes. Female bostrichids lay eggs generally in cracks and crevices of bark.

The larval stage feeds on wood, which causes the damage. As the larvae feed, they create tunnels that become filled with powder frass. Their tunneling and development occur entirely below the wood surface.

Pupation occurs once a larva is full grown. The pupal period lasts several weeks or even months before the adult beetle emerges through a hole cut to the wood surface. Depending on the species, the exit hole may be cut by the emerging adult or full-grown larva. Larvae often retreat into an enlarged pupal chamber just below the exit hole and plug it. The adult then removes the frass plug and exits through the hole. Adult emergence generally occurs from April – July.

**CONTROL AND MANAGEMENT OF POWDERPOST BEETLES**

Periodic inspections are needed to determine the condition of the wood and to locate any evidence of damage by wood-destroying beetles.

- Visually examine all exposed surfaces of the wood (painted and unpainted); also check by tapping or probing wood with a knife.
- Interview homeowner or building occupants and ask whether they have noticed any signs of beetle infestation (beetles, holes in wood, frass, etc.).
- Look for evidence of beetle attacks in attics, crawl spaces, unfinished basements and storage areas. The signs are more often absence of finishes on the wood, which leaves wood surface exposed to reinfestation.
- To be certain that the infestation is active, try to find fresh frass (which is the color of freshly shaved wood), live larvae or adults in wood.
- Most all century homes in Ohio will have evidence of powder post beetles.

Alteration of environmental conditions might one day be the only procedure necessary to eliminate some infestation of wood-boring beetles. No wood destroying beetles develop rapidly in dry wood. If the use of vapor barriers, ventilation, and central heat can dry wood, and keep it dry, other controls may not be needed. Some techniques to reduce favorable habitat for wood-destroying beetles include:

- Moisture meters can be used to determine the moisture level in the wood. Every effort should be made to reduce the moisture content of the wood to be protected to below 20 percent.
- If possible, infested wood should be removed and replaced.
- Electric current treatment and heat control may be used in some wood-boring beetle infestations.

There are certain similarities in control measures recommended for the control of wood-boring beetles but in many instances, specialized techniques are
required. If it is determined that the damage is from lycid powderpost beetles, then concentrate control measures on hardwoods. This will involve a thorough application of insecticides to all exposed hardwood surfaces.

If the infestation involves bostrichid or anobiid beetles, the scope of the application is altered to some extent. Unless the applicator can make a definite species determination, they must assume the beetles attack both hard and soft woods and perform the necessary treatment. Each infestation must be analyzed for severity, the possibility of reinfection, and the area of the structure being attacked.

- Residual sprays provide effective control in most cases. Sprays should be applied at low pressure (to reduce splashing) to unfinished wood using a flat-fan nozzle to obtain thorough coverage.
- The best penetration to tunnels is provided by a fumigant, which requires a 10c Fumigation category added to license. There is considerable danger in handling this material and it is also a restricted-use product. In addition, fumigants have no residual activity. In most cases, water-based insecticide emulsions are considered safer and more effective than oil based emulsions. Oil solutions present a possible fire hazard, greater expense, greater hazard, discomfort to the applicator, and danger of damaging plants.
- Do not allow any treated surface to be walked on or handled until it is thoroughly dry.
SECTION 4

Rats, Mice, and Voles

A few vertebrates like rats and mice are common pests in urban and industrial sites. Others are not pests in their normal habitats, but when they encounter humans, they become pests.
CHAPTER 18  
RATS, MICE, AND VOLES

LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Know the appearance, habits, and habitats of rats, mice, and voles
- Be familiar with diseases spread by rats, mice, and voles
- Be able to describe monitoring procedures and tools used to inspect for rats, mice, and voles
- Be able to describe lethal and non-lethal methods of controlling rats, mice, and voles
- Know the various control methods used in rat, mouse, and vole control

NORWAY RATS

Rats cause more human suffering and economic damage than any other vertebrate pest. They caused plague epidemics (the “Black Death” of Europe) and rat-bite fever. Rats are enemies of humankind because of the damage they do while feeding on electric wires, stored grain, etc. Statisticians estimate that rats destroy 20 percent of the world’s food supply every year by direct feeding and indirect contamination.

Rats have adapted to most human environments. They live in granaries, fields, city sewers, ocean-going ships, rooftops, attics, basements, streets, trees, on top of 30-story buildings, and inside subway tunnels.

Rats are adept athletes who can leap 3 feet straight up and 4 feet horizontally. They can scramble up the outside of a pipe 3 inches in diameter. Rats can climb inside pipes 1 1/2 to 4 inches in diameter. They can walk between buildings on power lines. They scramble on board a ship on its mooring lines. Rats can swim a half mile of open water, tread water for up to three days, and swim against a strong current in a sewer line, and dive through a sewer trap to come up inside a toilet. Rats can fall more than 50 feet and survive.

Rats gnaw constantly. Their teeth are extremely hard. They commonly chew through building materials like cinder block, aluminum siding, wallboard, wooden cabinets, lead sheathing, and plastic or lead pipes. After gnawing a hole, an adult rat can compress its body and squeeze through an opening only 1/2 inch high.

In most instances, rats are very wary. Hundreds may be nesting in a city block. They are in underground burrows, in sewers, on roofs, inside buildings, without people even knowing about it. Rat populations are dynamic; rats moving in, rats moving out, rats giving birth, and rats dying. Within a population, some rats will be easy to control, while some will be difficult.

Successful long-term rat control is not simple. The key is to control rat populations, not individual rats. Rat control requires an integrated approach that includes non-lethal tools such as careful inspection, upgraded sanitation and rat-proofing structures. Lethal control often combines the use of rodenticides with non-toxic control measures such as snap traps or glue boards.

RATS AS DISEASE CARRIERS

Rats are responsible for the spread of many diseases. Sometimes they transmit the disease directly by contaminating food with their urine and feces. Sometimes they transmit diseases indirectly. For example, fleas may first bite an infected rat then a person. Some important diseases associated with rats are as follows:

Plague – The Great Plague of London killed half of the city’s population. The Black Death of Europe in the 14th century lasted 50 years and killed 25 million people. In the first quarter of this century an estimated 11 million people died in Asia from plague. The disease is transmitted to humans primarily by the oriental rat flea. The flea bites an infected rat and then feeds on a human, which inoculates them with the bacteria that causes the
disease. Even though there has not been an outbreak of it since 1924, there is still a reservoir of it in population of wild rodents. Humans contacting these rodents could contract the disease. The symptoms of plague include sudden the onset of fever with painful swelling of lymph nodes. If the infection moves which is known pneumonic plague, it produces pneumonia that is highly contagious and often fatal. As suburbia expands into undeveloped areas, wild rodents can transmit the disease to urban rats. An outbreak of urban plague could occur in the United States.

Murine Typhus Fever – Murine typhus occurs in California as well as southeastern and Gulf Coast states. It is a relatively mild disease in humans. As with plague, murine typhus is transmitted from rats to humans by a rat flea. In this case, the disease organism enters the bloodstream when feces of infected fleas are scratched into a flea bite wound. Symptoms may include fever, severe headache, or rash.

Rat-bite Fever – Rats bite thousands of people each year. Most bites occur in inner cities. Victims, particularly infants and bed-confined elderly, are bitten in the face while sleeping. A small percentage of those bitten develop rate-bite fever. The bacterium that causes the disease is carried in the teeth and gums of many rats. In most cases, the disease exhibits mild symptoms similar to those of the flu. It can be fatal and it is of particular risk to infants.

Salmonella Food Poisoning – Rats frequent sewers, rotting garbage, cesspools, and similar sites where Salmonella bacteria thrive. The bacteria also thrive in the intestinal tracts of rats. If infected rats travel to stored food, dishes and silverware, or food preparation surfaces, their droppings can transmit Salmonella food poisoning to humans. Symptoms of food poisoning may include headache, stomach pain, diarrhea, and low-grade fever.

Leptospirosis or Weil's disease – Human cases of this disease are seldom fatal. The disease organism is spread from rat urine into water or food. It enters humans through mucous membranes or minute cuts and abrasions of the skin. The disease may be so mild that it goes unnoticed or may cause mild aches, pains, and fever. Cases that are more serious, which are often referred to as Weil’s disease can result in high fever, jaundice, aseptic meningitis, acute kidney failure, internal bleeding, and occasionally death.

Trichinosis – Trichinosis results from a nematode or tiny roundworm that invades intestines and muscle tissue. Both people and rats get the disease from eating raw or undercooked pork infected with the nematode. Rats help spread trichinosis when hogs eat food or garbage contaminated with infested rat droppings. Symptoms may include vomiting, diarrhea, and abdominal pain.

Rabies – Rats in native habitats have not been found with rabies. Rabies transmission from rats to humans has never been documented in the United States. The U.S. Public Health Service recommends against anti-rabies treatments in the case of rat or mouse bites.

THE NORWAY RAT
The common rat found in Ohio is the Norway rat (Rattus norvegicus). The Norway rat is also called the brown rat, house rat, sewer rat, and wharf rat. The Norway rat is considered the most important rat pest in the U.S. It is found in every state.

Habits of Rats - Rats must be understood to be controlled. Knowledge of their life cycles, habitat, food needs, behavior, range, and other factors are essential to their management.

Life Cycle - A mature female rat can give birth to about 20 young in a year. The average life span of a rat in the field is less than one year. Female rats live longer than males. The young are born in a nest. They are hairless and their eyes and ears are closed. The young rats open their eyes and ears in about two weeks. They soon become furry and start exploring the nest area as well. During the third week, they begin to eat solid food and imitate their mother to forage for food and watch for danger.
If the mother rat has become wary of rodenticides or traps, many of her young will learn to avoid them. This learning skill can make control difficult. Control can be hard in sites where long-term rodent-control programs have failed in the past. Young rats are weaned at 4 to 5 weeks old. They weigh about 1 1/2 ounces. At 3 months, they are independent of their mother. They will mate and continue the cycle in the same or in a new area.

Social Behavior - Rats are social animals and live in colonies. They have territories that are well defined with urine and glandular secretions. The rat colony has a complex social hierarchy with a dominant male leader and a “pecking order” of subordinate males and ranking females. The strongest and most dominant animals occupy the best nesting and resting sites and feed at their leisure. Weaker subordinates are pushed out to less favorable sites or forced out of the territory completely.

Rats are aggressive and social conflicts are most common at feeding sites, resting areas, and territorial boundaries. Females fiercely defend their nests and young from other rats.

Senses of Rats - Rats have poor vision. They are nearly color-blind. They react to shapes and movement instead of identifying objects by sight. The limit of their vision is 30 to 45 feet. Their eyes have adapted to dim light.

Their other senses make up for the poor vision. They use the sense of smell to locate food, follow pathways, tell if another rat is friend or foe, and identify new objects in their territory. They use long whiskers and guard hairs to “touch” their way through dark burrows, pipe chases, wall voids, and other runways. Their ears detect faint sounds that signal danger. Rats can taste certain chemicals at parts per million concentrations. This explains why rats often reject baits or avoid traps that have been contaminated. Finally, rats have an excellent sense of balance that allows them to walk on wires and always land on their feet.

Fear of New Objects (Neophobia) - Rats are wary of anything new in their territory. A bait station, trap, block of wood will be avoided. New things will be avoided a few days until the rats become familiar with the new object. Even after familiarity, they approach with caution. The fear of new objects can make baiting and trapping difficult. Rats will avoid poison bait when it is first placed. Later they may nibble warily. If the poison bait makes them ill but does not kill them, they will avoid similar baits or stations in the future.

Food and Water - Rats need about 1 ounce of food daily. Norway rats prefer protein-based foods such as meat, fish, insects, pet food, nuts, and grain. Household garbage is ideal food for Norway rats. They will feed on non-preferred food if nothing else is available.

Rats often hoard food in hidden areas. They may or may not eat this food when other food supplies run short. Hoarding is important for two reasons. First, rats may be moving toxic bait into a location where the label does not permit it to be. Secondly, rats may be hoarding poison bait while feeding on their regular food. Thus, a baiting program becomes ineffective.

Rats need water every day. The amount varies depending on the moisture content of their food. The amount of moisture needed is usually around 1/2 to 1 fluid ounce. Rats prefer to nest where water is easily available.

Range - Rats usually begin foraging just after dark. Most of their food gathering occurs between dusk and midnight. They do have short bursts of restlessness and activity can occur anytime day or night. Rats commonly travel 100 to 150 feet from their nests looking for food and water and patrolling their territory. It is not unusual for a colony of rats that nests outdoors to forage inside a building 100 feet away.

Nests - Outside, Norway rats usually nest in burrows dug into the ground. The burrows are shallow (less than 18 inches) and usually short (less than 3 feet) with a central nest. Extra “bolt holes” are used for emergency escapes. They are hidden under grass or boards or lightly plugged with dirt. Burrow openings are 2 to 4 inches in diameter. Norway rats that tend to live indoors nest inside walls, in the space between floors and ceilings, underneath equipment, between and under pallets, in crawl spaces, storage rooms, and any cluttered area that is normally unoccupied. Norway rats prefer to nest in the lower floors of a building.

They also nest in sewers, storm drains, and on occasion, they can be found in highly unusual nest sites. Norway rats can have several “hotel” nest sites in an area. A rat may spend a week in its home base and then move for a day or two into a secondary “hotel” nest site. Norway rats have been shown on occasion to have a home range of up to 20 acres when these secondary nest sites were included in the calculations.
Inspection - Rats give many signs that they are infesting an area. Inspection will determine if a site is infested and will identify where rats are feeding and nesting. It will also determine their patterns of movement, the size of the population, and the extent of the infestation. This helps the pest control technicians decide what control measures to use, where and how to use them, and how much effort is needed to put the program in place.

Flashlight – An inspection using a powerful flashlight just after dark is the best way to see rats. Dead rats are signs of a current or past infestation. If all that are found are old dried carcasses and skeletons, it may mean an old infestation. Many fresh carcasses are an indication that someone may be baiting the area currently. If rats are actively observed during the day, the rat population is probably high.

Sounds – When a building is quiet, squeaks, fighting noises, clawing and scrambling in walls, or gnawing sounds may be heard.
  ▪ Use a stethoscope or electronic listening device to help pinpoint activity.

Droppings – A single rat may produce 50 droppings daily. Norway rat droppings are 3/4 inch long. The highest number of droppings will be found in location where rats rest or feed.
  ▪ Determine if a rat population is active by sweeping up old droppings, and then reinspect a week later for new droppings.
  ▪ Look at the appearance of the droppings to determine if rats are currently active. Fresh rat droppings are black or nearly black. They may look wet, and have the texture of putty. After a few days or a week droppings become dry, hard, and appear dull. After a few weeks, droppings become gray and dusty and crumble easily. Note: Old droppings moistened by rain may look like new droppings, but when crushed, they will crumble.

Urine – Both wet and dry urine stains will glow blue-white under an ultraviolet light (black light).
  ▪ Use portable ultraviolet lights developed by the food industry to identify rat urine on foot items.
  ▪ Other substances besides rate urine also glow, so proper use of this inspection method takes practice.

Grease Marks – Oil and dirt rub off the rat’s coat as it scrambles along. The grease marks build up in frequented runways and become noticeable.
  ▪ Look along wall/floor junctions, on pipes, ceiling joists, and on sill plates where rats swing around obstacles. Grease marks are also found at regularly used openings in walls, floors, and ceilings.

Runways – Rats constantly travel the same route outdoors. Their runways appear as beaten paths on the ground. Look next to walls, along fences, under bushes and buildings. Indoor runways, which are harder to identify, may appear as well polished trails that are feed of dust.

Tracks – A rat’s footprint is about 3/4 inch long and may show four or five toes. Rats may also leave a tail dragline in the middle of their tracks.
  ▪ Look for tracks in dust or soft moist soil.
  ▪ Place a tracking patch in suspected rat areas to show footprints. A tracking patch is a light dusting of an inert material such as clay, talc (unscented baby powder), or powdered limestone. Do not use flour, because it may attract insect pests. A good patch size is 12 by 4 inches. Apply patches in suspected runways and near grease marks. When inspecting tracking patches, shine a flashlight at an angle that causes the tracks to cast a distinct shadow. Note that a tracking patch is not the same as tracking powder. Tracking powders are diluted rodenticides in dust form. Tracking patches use non-toxic dust. Do not use a tracking powder to make a tracking patch.

Gnawing Damage – A rat’s incisor teeth grow at a rate of about 5 inches per year. Rats keep their teeth worn down by continuously working them against each other and by gnawing on hard surfaces.
  ▪ Look for gnawing damage as evidence of a rat infestation. Gnawed holes may be 2 inches or more in diameter.
  ▪ Inspect floor joists, ceiling joists, floor corners, kitchen cabinets, and around pipes in floors and walls.

Burrows – Outdoor rat burrows may be found singly or in groups along foundation walls, under slabs and dumpster pads, in overgrown weed areas, beneath debris, and in embankments.
  ▪ Look for a burrow opening that is free of dirt, leaves, and debris, often with smooth, hard packed soil.
  ▪ Look for rub marks at the opening and soil pushed out in a fan shaped pattern.
• Fill the opening with a small amount of wadded-up newspaper or a few leaves and cover it with loose soil. If the rats are still using the burrow, they will reopen and clear the hole overnight.

Figure 18.5 Norway rat teeth (Image Courtesy of Bugwood.org)

Odor - Heavy infestations have a distinctive odor that can be identified with practice. The odor of rats can be distinguished from the odor of mice.

Estimating Rat Numbers – It is not easy to tell how many rats are infesting a site. As a rough guide you can use rat signs to characterize the population as low, medium, or high.

• In rat-free or low-infestation conditions, no signs are seen. The area either has no rats or was invaded recently by a few.
• With medium infestations, old droppings and gnawing can be observed. One or more rats may be seen at night, and no rats will be seen during the day.
• When there is a high infestation, fresh droppings, tracks, and gnawing are common. Three or more rats will be seen at night, rats may be seen in the daytime.

CONTROL AND MANAGEMENT OF RATS
The most successful rat control programs use a combination of tools and procedures to knock down the rat population and keep it down. Most methods used combine habitat alteration and pesticide application. Some of the tools, like baiting and trapping, are lethal to the rats. Some tools are NOT lethal. For example, an applicator may simply recommend changes their customers need to make. These changes may include tasks such as increase the number of times the garbage is picked up or making building repairs.

Food – Like all animals, rats need food to live. Baits often fail because they cannot compete with the rats’ regular food. The rats simply ignore the baits or hoard them. Reducing the rats’ food makes them feed on available baits placed in their territory.

• Close or repair dumpsters and garbage containers that are left open or are damaged.
• Clean up food spills
• Do not allow food to be left out overnight.
• Remove seed spilled outdoors under bird feeders or food around doghouses.
• In warehouses and food plants, look for spills around railroad tracks and loading docks. Ensure food in storage is rotated properly (first in, first out) and is stored on pallets not on the ground or against walls. The pallets should be 18 to 24 inches from sidewalls and placed so that aisles permit inspection and cleaning around the stored food.
• Remove plant ground covers such as ivy near buildings.
• Remove high grass, weeds, woodpiles, and construction debris that permit rats to live and hide adjacent to a building.
• Reduce clutter in rarely used rooms such as basements, storage rooms, and equipment rooms.
• Organize storage areas.

Rat Proofing – In the long term, the most successful form of rat control is to build them out. This approach is called rat proofing and makes it impossible for rats to get into a building or an area of a building. Rat proofing prevents new rats from reinfesting a building once it has been cleared.

• Seal cracks and holes in building foundations and exterior walls
• Block openings around water and sewer pipes, electric lines, air vents, and telephone wires.
• Screen air vents.
• Caulk and seal doors to ensure a tight fit. This is especially important between door and floor threshold areas.
• Repair breaks in the foundation below ground level.
• Seal spaces inside hollow block voids or behind wallboards. Repair broken blocks and holes around pipes.
• Repair gnawed holes or stuff them with copper wool.
• Equip floor drains with sturdy metal grates held firmly in place.

Rodenticides – A rodenticide is a pesticide for killing rodents. There are three major types of rodenticides. They are as follows:

• Food baits
• Water baits
• Tracking powders

Food baits – Rat baits combine a poison effective against rats with food bait attractive to rats. At one time applicators mixed their own baits. Now baits are mostly purchased ready made. Baits are made of extruded pellets, in a dry meal, or molded into paraffin blocks for wet sites. Baits come in 45-pound bulk tubes in place packs.
containing less than 1 ounce of bait or anything in between.

Some baits kill rats after a single feeding, but some require multiple feedings. Some are anticoagulants (causing internal bleeding), while others affect respiration, and others have different modes of action. Baits range from being slightly toxic to very toxic to humans.

Many ancient poisons that are toxic to humans have been used to poison rodents. Experimentation with poisons for killing rodents produced rodenticides made of arsenic, cyanide, strychnine, etc. These stomach poisons were mixed with food and had such extreme toxicity that they killed any animal that ingested them in sufficient amounts. Rats that did not eat a lethal dose recovered and became bait shy. They also communicated their preference or revulsion to others in the colony. Due to this problem, these poisons were undependable.

A new type of rodenticide was developed in the 1940s that reduced the clotting ability of the blood. This material, known as warfarin became the first anticoagulant rodenticide. Others such as, coumafuryl, chlorophascinone, diphascinone, pindone, and valone followed warfarin. The anticoagulants were effective and did not cause bait shyness. Animals like poultry, farm animals, pests and humans would have to consume large quantities over several days for fatalities to occur.

Evidence of resistance to anticoagulants and a desire for quicker results drove the successful search for single dose anticoagulants like brodifacoum and bromadiolone. In recent years, non-anticoagulant rodenticides with different modes of action like bromethalin or cholecalciferol have proven effective. Zinc phosphide used as a single dose non-anticoagulant is somewhat poisonous to all vertebrates. It is often used as a tracking powder that rodents lick from their fur during grooming. It is also incorporated in dry baits. **Zinc phosphide should never be mixed with bare hands nor applied without wearing gloves.**

Remember, rodenticides must be used very carefully. They are made to kill animal species of the same class as humans.

**Baits**
- When using baits do not contaminate with pesticide sprays this will repel rats from feeding on baits.
- Check bait stations and change locations often.

**Bait Boxes** – A tamper proof bait box is designed so that a child or pet cannot get to the bait inside but the rat can. Bait trays and flimsy plastic or cardboard stations are not tamper proof bait boxes. Tamper proof boxes vary in type and quality of construction. They are usually made of metal or heavy-duty plastic. Rat bait stations are normally larger than those used for mice. Most designs are not considered to be truly tamper proof unless they can be secured to the floor, wall, or ground.

![Figure 18.6 Rodent Bait Box (Image courtesy of bugwood.org)](image)

- Ensure that bait boxes are clearly labeled with a precautionary statement.
- Check stations or boxes periodically to make sure that rats are taking the bait and that the bait is fresh. Rats will rarely feed on spoiled bait.
- Bait boxes should be placed wherever the rats are most active as determined by droppings and other signs.
- Put bait packs in burrows, in wall voids, and similar protected sites. If a site is damp, use paraffin, bait blocks or other water resistant formulations. Put out enough bait and check it often. Incomplete baiting can lead to bait shyness and make control difficult.
- Be sure to limit the rats’ normal food supply or your baits may be rejected.
- Remember that rats fear new objects at first so your baits may not be taken for a few days or a week.
- Once bait is taken, leave the box in place for sometime. The rats now consider it part of their normal surroundings.
- Good bait placements can be effective even when placed 15 to 50 feet apart. Bait placed outdoors around a commercial building can kill rats that are moving in from nearby areas.

**Water baits** – Rats drink water daily if they can. When rat water supplies are short, water baits which are specially formulated rodenticides that are mixed with water can be extremely effective. Several types of liquid dispensers are available. The best are custom designed for toxic water baits, but plastic chick founts can also be used in protected sites. **Use water baits only where no other animals or children can get to them.**
Tracking Powders – Rats groom themselves by licking their fur. Tracking powder makes use of this behavior. This formulation is a rodenticide carried on a talc or powdery clay that is applied into areas where rats live and travel. The powder sticks to the rats’ feet and fur. Then it is swallowed when they groom. The major advantage of tracking powders is that it can kill rats even when food and water are plentiful or if rats have become bait or trap-shy.

Apply tracking powders more heavily than insecticide dust but never deeper than 1/8 inch. Best application sites are inside wall voids, around rub marks, along pipe and conduit runs, and in dry burrows. Apply with a hand bulb, bellows duster, or with a flour shifter or saltshaker.

Do not use tracking powders in suspended ceilings, around air ventilators, or near food or food preparation areas. The powders can become airborne and drift onto non-target areas. The rodenticide in tracking powders is generally 5 to 40 times more concentrated than that in baits. Tracking powders can be made with acute poisons or slower acting poisons.

THE HOUSE MOUSE
The house mouse (Mus musculus) easily adapts to life with people. It thrives in a wide range of climates and habitats. It feeds on most human foods and reproduces at a remarkable rate.

House mice are found throughout the U.S. and in most areas of human habitation. House mice are also found living in the wild competing with native mice. They are common in grassy fields and in cultivated grain crops. House mice have even been captured in open tundra of Alaska miles away from humans.

Technicians will find that the house mouse is a troublesome and economical important rodent. House mice are a common problem in homes and all types of businesses. Nearly everyone can remember when mice irritated them. Mice are nuisances to rich and poor alike. The continual drain the house mice cause on stored food and fiber and the damage they cause. They damage personal possessions and are the economic threat to humans.

Control of house mice requires an understanding of mouse biology and habits. During the past few decades, control of rats has improved while the problems with house mice have increased. Baiting programs often are more successful in controlling faster than they are in controlling mice.

Losses Due to Mice – When mice infest stored grain, the greatest loss is what is thrown out because of contamination not what they eat. One pair of mice in one month can eat 4 pounds of food and deposit about 18,000 droppings. The estimated food contaminated about 10 times what they eat.

Mice are so common that the government allows a certain amount of rodent hairs and sometimes droppings in food commodities for human consumption. Many times food inspectors have to condemn food products and fine manufacturers because contamination is over the amounts permitted.

Food products are not the only losses. Mice damage family Bibles or heirlooms stored in an attic. They damage original paintings and manuscripts stored in museums. Mouse riddled documents of an office generally cannot be valued but losses are still costly.

Electrical wiring gnawed by rodents has started many fires. Many fire related incidents listed as “cause unknown” might be rodent related. House mice frequently take up residence in electrical appliances and chew the power cords. This is very costly when computer systems are disrupted.

MICE AS DISEASE CARRIERS
Excluding the spread of food poisoning, house mice are not as important disease carriers as rats. However, their potential cannot be overlooked. House mice and their parasites are implicated in transmitting a number of diseases.

Salmonella Food Poisoning – The spread of bacterial food poisoning like salmonellosis is caused by contaminated food with mouse feces. Mice are probably more responsible than rats for the spread of this disease.

Rickettsial Pox – Rickettsia akari is a causal agent rickettsial pox. It is a rash of the chicken pox type. Rickettsial pox is transmitted from mouse to mouse. It is then transmitted from mouse to human by a bite from a mouse.

Meningitis – Lymphocytic choriomeningitis is a virus infection of house mice that may be transmitted to people (mainly children) through contaminated food or dust.

Leptospirosis (Weil’s disease) – The mouse can be a major carrier of Leptospirosis (Weil’s disease), but human cases is more commonly caused by rats.

Rat-Bite Fever, Ray Fungus, and Ringworm – Rat-bite fever, Ray Fungus, and Ringworm can be transmitted by house mice. Certain tapeworms are spread in house-mouse droppings. Ringworm, a skin fungus disease, can be carried to humans by mice or contracted indirectly from mice through cats. Tularemia has also been linked to house mice.

Dermatitis – Dermatitis caused by the bites of mites have been associated with house mice infestations. The uncomfortable skin irritation and itching can affect...
children and adults. Mites may spread through all of the mouse-infested house or apartment during particular times of the year. Dermatitis is frequently blamed on other causes like heat rash, allergies, fleas etc.

Appearance – The house mouse is a delicate agile little rodent. Adult weights vary from region to region and may be linked to suitability of habitat. The house mouse usually weighs from 1/2 to 1 ounce. Adult house mice vary in color from light brown to dark gray. They are most often dusky gray or medium brown over most of their bodies except the belly that may be a lighter shade but never white.

![Figure 18.7 House Mouse](image.png)

The house mouse has moderately large ears for its body size. The tail is nearly hairless and about as long as the body. With head combined, they are 2 1/4 to 4 inches long. The feet are small compared to the size of its body. Their eyes are relatively small as well.

Life Cycle – Under optimum conditions, house mice breed year round. Outdoor house mice may breed seasonally with peak times during the spring and fall. Conditions such as available food and its quality have an effect on the frequency of pregnancies, litter sizes, and survival. Under ideal conditions, females may produce as many as ten litters (about 50 young) in a year. At very high populations, reproduction may nearly cease even though there is plenty of food, water, and cover.

Newborn mice are quite helpless. Their weight is between 0.02 and 0.03 ounce and they are nearly hairless. Mice’s eyes and ears are closed, but by the end of two weeks, the body is covered with hair and the eyes and ears are open. At about three weeks, the young begin short trips away from the nest and begin taking solid food.

Social Behavior – Mice are usually active at night but some day activity occurs. Temperature, food, and hiding places affect the movements of house mice. Home ranges of house mice tend to be small and where living conditions are good.

Mice tend to travel over their entire territory daily. They check out each change or new object that may be placed there. They are very aggressive. Unlike rats, they show no fear of new objects and they dart from place to place covering the same route. This type of action can be an advantage in control programs. Messing up the territory as you begin a control program may work to your advantage. Moving boxes, shelves, pallets and other objects can improve how well traps, glue boards and baits work. Mice will check out the changed territory thoroughly.

Senses of Mice – Like rats, mice have poor vision and are color-blind. They rely on smell, taste, touch and hearing. Mice use their keen sense of smell to locate food and to make out other mice (mainly those of the opposite sex). Taste perception in mice is good as well. Mice use their acute hearing to detect and escape danger.

An important sensory factor with mice is touch. Like rats, mice use long sensitive whiskers near the nose and guard hairs as sensors that allow them to travel in the dark. They press against walls, boxes and scurry through burrows.

Mice also have a great sense of balance. A mouse’s ability to carry out actions or movements is an on going series of movements sometimes called kinesthetic sense. The kinesthetic sense is a subconscious recording of a series of movements to go from point A to point B. This happens when stimulus of sensory nerve endings in muscles, tendons, and joints allow mice to get away from danger.

Curiosity – Mice do not fear new objects as rats do. As mentioned before, they detect new objects in their territory and explore them. They will instantly enter bait stations and sample new food (it may only be a nibble). They will explore traps and glue boards as well. Control programs against mice often have success early unlike that of rat programs.

Physical Abilities – It is difficult to mouse-proof a building or control mice without understanding their capabilities.

- For their size they are very good jumpers with some of the more agile individuals jumping 12 inches high from the floor onto an elevated flat surface
- They can jump against a wall or flat vertical surface and use it as a springboard to gain additional height
- They can run up almost any vertical surface from wood and brick walls to metal gliders, pipes, weathered sheet metal, wire mesh, and cables, without much difficulty if the surface is rough
- They can run horizontally along insulated electrical wires, small ropes, and the like, with ease
- They can squeeze through openings slightly more than 1/4 inch in diameter
- They can easily travel for some distance hanging upside-down from 1/4 inch hardware mesh
- They are capable swimmers, although they generally do not take to water as well as rats do, and tend not to dive below the surface
- They can walk or run along ledges too narrow for rats
- They can jump from a height of 8 feet to the floor
- They can survive a constant 23° F temperature for 10 generations
- They have been reported 1,800 feet below the ground in a coal mine
- They are quick to explore any physical change in their environment

Food and Water – House mice prefer cereals. However, mice will feed on a wide variety of foods. Mice sometimes search for foods high in fat and protein. These foods are lard, butter, nuts, bacon, meat, sweets, and chocolate. Mice get much of their water from moisture in their food, but they will drink if water is available.

Mice are nibblers feeding 20 or more times during evening rounds. Mice have two main feeding periods at dusk and just before dawn. In any territory, there will be one or two feeding sites dark and protected. Mice tend to hold grain kernels such as oats or wheat nibbling on them like people eating corn on the cob. They often drop portions of the kernels when they get smaller.

Range – Mice are territorial and seldom travel more than 30 feet from their nests. Their range is much smaller than the rat’s range of 100 to 130 feet. When food is nearby mice may restrict their activity to a few feet. Males average slightly larger ranges than females.

Nests – House mice may nest in any dark sheltered location. Mice construct their nests of fibrous shredded materials such as paper, cloth, burlap, insulation, or cotton and generally look like a loosely woven ball. They are about 4 inches in diameter.

Outdoors house mice sometimes dig and nest in small burrows.

The small range of mice, the way they feed, and their food preferences are the characteristics that set mice apart from rats. Keep these in mind when controlling mice. Many failures in mouse control can be blamed on applicators using rat control techniques.

Sounds – Sounds are common at night where large numbers of mice are present.
- Look along runways by food near shelters and in other places mice may frequent.

Droppings – A house mouse produces about 70 droppings per day. Fresh droppings are not usually as soft as rat droppings and in a few days become quite hard. Mouse droppings are frequently the first evidence that mice are infesting. Large cockroaches, bats, and other species of mice, such as deer mice and meadow mice, may produce droppings similar to those of house mice.
- Look along runways, by food, near shelters, and in other places mice may frequent.

Urine – House mice occasionally make small mounds known as “urinating pillars.” These consist of a combination of grease, urine, and dirt and may become quite conspicuous.
- Look for many small drops of urine.
- Use a black light. Urine stains will fluoresce under ultraviolet light.

Grease Marks – Like rats, mice produce greasy smears where dirt and oil from their fur make contact with pipes and beams. House mice spots are not as easy to detect.
- Expect marking to cover a smaller area than those made by rats.

Runways – Most house mice runways are indistinct trails that are free of dust but not readily detectable

Tracks
- Look for footprints or tail marks on dusty surfaces or on mud
- Use a non-toxic tracking dust to help determine the presence of house mice within buildings (see chapter on rats)

Gnawing Damage – Recently created gnawing marks on wood are light colored and they turn darker with age.
- Look for enlarged cracks beneath doors.
- Look for small tooth marks. Such evidence frequently helps to distinguish between mice and rats.
- Look for wood chips with a consistency like those of coarse sawdust around baseboards, doors, basement windows and frames, and kitchen cabinets.

Visual Sightings – Mice are often active in daylight. This may not indicate a high population as it does with rats.
- Use a powerful flashlight or spotlight at night in warehouses and food plants to confirm house mouse presence.

Nest Sites –
- Look in garages, attics, basements, closets, and other storage places.
- Be alert to finely shredded paper or other fibrous materials. These are common nest building materials.

Pet Excitement –
- Follow up when cats and dogs paw excitedly at a kitchen cabinet door, the floor at the base of a refrigerator, or at the base of a wall (especially if mice have invaded the premises only recently.)
Mouse Odors –
- Smell for the characteristic musky odor produced by mice. It can easily be differentiated from that or rats.

CONTROL AND MANAGEMENT OF THE HOUSE MOUSE

Control of house mice is a three-part process:
- Sanitation
- Mouse-proofing
- Population reduction with traps or toxicants

The first two are useful preventive measures. When a mouse population already is there some kind of lethal control is necessary. The reproductive capability of the mice and the remarkable ability to find food in almost any habitat will keep their population up or increase them.

House mouse control is different from rat control. Applicators who do not consider these differences will have control failures.
- Sealing mice out of a building is difficult because mice are smaller.
- Range is small. Identify each infested site to target control procedures.
- Mice often can produce offspring faster than control methods can work.

Nevertheless, many of the techniques to control and manage rats also apply to mice. In the sections below, the differences in procedures for rats and mice are emphasized.

Sanitation – Good sanitation makes it easier to detect signs of mouse infestation. It also increases the effectiveness of baits and traps by reducing competing food. However, the best sanitation will not eliminate house mice. They require very little space and small amounts of food to flourish.
- Store foods in mouse-proof containers in rooms. In warehouses, restaurants, and food plants stack packaged foods in orderly rows on pallets so that they can be inspected easily. A family of mice can happily live in a pallet of food without ever having to leave the immediate area.
- Keep stored material away from walls and off the floor. A 12 to 18 inch yellow or white painted band next to the wall in commercial storage areas permits easier detection of mouse droppings. The band and the areas around pallets should be swept often so that new droppings detected quickly.

Mouse Proofing – It is not easy to completely mouse-proof a building because mice are reported to be able to squeeze through an opening as little as 1/4 inch in diameter.
- Seal large holes to limit the movement of mice into and through a building.
- Plug holes in foundation walls with steel wool or copper mesh.
- Caulk and fit doors and windows tightly.
- Seal holes around pipes, utility lines, vents, etc., to make it difficult for mice to move in and out of wall and ceiling voids. This confines mice to a smaller area and may make snap traps and glue boards more effective.

Rodenticides – Food baits. Observe the same safety guidelines for mouse baits as discussed in the section on rat baits. Protect children, pets, wildlife, and domestic animals by putting the bait in inaccessible locations or inside tamper-proof bait boxes.
- Apply many small bait placements rather than a few large placements.
- Use baits labeled for mouse control.
- Place the baits in a favorite feeding spot. Large numbers of droppings reveal resting sites.
- Place baits between hiding places and food up against a wall, or other objects to intercept the mice.
- Bait in three dimensions
- Make bait placements 10 feet apart or closer in infested areas.
- If mouse bait is refused, try switching to a different type and replacing the baits often.
- Use small bait stations. They are more attractive to mice than the larger rat-type stations.
- Practice strict sanitation so that other food is not out competing the baits.
- Place secure tamper-proof bait boxes in safe location near doors in late summer to intercept mice entering from the wild.

Liquid Baits - Mice get most of their water from their food. They also drink from water containers. Liquid baits that are labeled for mouse control can be effective in sites that do not have a ready supply of water. The same water bait dispensers used for rats can be used for mice. As with food baits and traps, many water stations will be necessary to put the bait into the territory of all mice infesting a building.

Tracking Powders – Tracking powders are especially effective against mice. Mice groom themselves more than rats and they investigate enclosed areas that can be dusted with tracking powder.
- Apply inside infested dry wall voids.
- Dust tracking powder into voids in heavily infested apartment or office buildings.
- Place tracking powder in bait station, a PVC tube, a cardboard tube, or a small dark shelter that a mouse could enter. Mice will explore a shelter. Apply the tracking powder in a layer less than 1/16 inch deep.
- Do not allow tracking to drift into non-target areas.
The two most common native mice species in Ohio are the deer mouse (*Peromyscus maniculatus*) and the white-footed mouse (*Peromyscus leucopus*).

All of the *Peromyscus* species have white feet, usually white bellies, and brownish backs. Their tails are long, sometimes as long as the head and body. The deer mouse has a distinct separation between the brownish back and white belly. Their tails are also sharply bi-colored and their eyes are more widely separated than those of white-footed mice. It is very hard even for an expert to tell all of the species apart.

In comparison to house mice, white-footed and deer mice have larger eyes and ears. They are deemed by most people to be “better looking” than house mice. White-footed and deer mice do not have the musky odor of house mice. All species of *Peromyscus* cause similar problems and require similar solutions.

**Life Cycle** – White-footed and deer mice are mostly nocturnal with a home range of 1/3 to 4 acres or larger. Summer populations may reach as high as 15 mice per acre.

Breeding occurs from spring until fall with a summer pause. This is the case in cooler climates. Litter size varies from 1 to 8 young but is usually 3 to 5. Females may have from 2 to 4 or more litters per year depending on species and climate.

During the breeding season, female white-footed and deer mice come into heat every fifth day until impregnated. The gestation period is usually 21 to 23 days but can be as long as 37 days in nursing females. Young are weaned when they are 2 to 3 weeks old. They become sexually mature at about 7 to 8 weeks of age. Those born in spring and summer may breed that same year.

Mated pairs usually remain together during the breeding season but may take new mates in the spring if both survive the winter. If one mate dies, they will get a new one. Family groups usually nest together through the winter. They do not hibernate but may become lazy for a few days when winter weather is severe.

**Nests** – Nests are made of stems, twigs, leaves, roots of grasses, and other fibrous materials. They may be lined with fur, feathers, or shredded cloth. The deer mouse often builds its nest underground in cavities under roots of trees or shrubs, under a log or board, or in a burrow made by another rodent. Sometimes deer mice nest in above ground sites like a hollow log or fencepost, or in cupboards and furniture of unoccupied buildings.

**Food Habits** – White-footed and deer mice are primarily seed eaters. Often they will feed on seeds, nuts, acorns, and other similar items that are available. They also consume fruits, insects, insect larvae, fungi, and possibly some green vegetation. They often store quantities of food near their nest sites mostly in the fall when food becomes abundant.

**Habitat** – The deer mouse lives in nearly every type of habitat within its range from forest to grasslands. It is the most widely distributed and abundant mammal in Ohio.

The white-footed mouse is also widely distributed but prefers wooded or brushy areas. It is sometimes found in open areas.

White-footed mice spend a great deal of time in trees. Formerly, much reforestation was attempted by direct seeding of clear-cut areas, but seed predation by deer, white-footed mice, other rodents, and birds caused failure. For this reason, to reestablish Douglas fir and other commercial timber species today, it is often necessary to hand-plant seedlings despite the expense.

**Damage** – The principle problem caused by white-footed and deer mice are their tendency to enter homes, cabins, and other structures that are not rodent-proof. Here they build nests, store food, and can cause considerable damage to upholstered furniture, mattresses, clothing, paper, or other materials they find suitable for their nest-building activities. Nests, droppings, and other signs left by these mice are similar to those of house mice. White-
footed and deer mice have a greater tendency to hoard food supplies like acorns, seeds, or nuts than do house mice. White-footed and deer mice are uncommon in urban or suburban residential areas unless there is considerable open space (fields, parks) nearby.

Both white-footed and deer mice occasionally dig up and consume newly planted seeds in gardens, flowerbeds, and field borders. Their very good sense of smell makes them highly efficient at locating and digging up buried seed.

Disease Carrier – In mid-1993, the deer mouse (P. maniculatus) was first implicated as a potential reservoir of a type of Hantavirus responsible for an adult respiratory distress syndrome. The disease leads to several deaths in the four corners of the U.S. The source of the disease is thought to be through human contact with urine, feces, or saliva from infected rodents.

Legal Status – White-footed and deer mice are considered native, non-game mammals and receive whatever protection may be afforded like species under state or local laws. It is usually permissible to control them when necessary but first check with your state wildlife agency.

CONTROL AND MANAGEMENT OF WHITE-FOOTED AND DEER MICE

Exclusion – Rodent proof construction is the best and most permanent method of preventing rodents from entering homes, cabins, or other structures. White-footed and deer mice require measures similar to those used for excluding house mice. No openings larger the 1/4 inch should be left unmodified. Mice will gnaw to enlarge such openings so they can gain entry.

Use folded hardware cloth (wire mesh) of 1/4 inch or smaller to protect newly seeded garden plots. Homemade wire screen caps or bowls can be placed over seeded spots. Bury the edges of the wire several inches beneath the soil. Plastic strawberry-type baskets inverted over seeded spots serve a similar purpose.

Habitat Modification – Store food like dry pet food, grass seed, and boxed groceries left in cabins in rodent proof containers.

Mouse damage can be reduced in cabins or other buildings that are not used often by reducing or limiting chances of possible nesting sites for mice. Remove padded cushions from sofas and chairs and store them separate from each other off the floor. Remove drawers in empty cupboards or chests, and put them in upside-down getting rid of nesting sites. Other techniques can be invented to outwit mice. Remember that the white-footed and deer mice are very good climbers. They often enter buildings by way of fireplace chimneys so seal off fireplaces when not in use.

When cleaning areas previously used by mice take precautions to reduce exposure to their excretions, and dead carcasses. Where deer mice have been there may be reservoirs of Hantaviruses. This area should be disinfected by spraying it thoroughly with a disinfectant or solution of household bleach prior to cleaning. Use proper protective clothing, including vinyl or latex gloves. Contact the Center for Disease Control (CDC) Hotline for current recommendations when handling rodents or cleaning areas previously infested.

Repellents – Mothballs or flakes (naphthalene) may repel mice from closed areas where enough concentration of the chemical can be in the air. These materials are not registered for repelling mice.

Toxicant – Anticoagulant baits like warfarin, diphenacine, chlorophacinone, brodifacoum, and bromadiolone are all quite effective on white footed and deer mice. Brodifacoum and bromadiolone may be effective in a single feeding. If baiting in and around structures is done for house mice in accordance with label directions, white-footed and deer mice usually will be controlled.

Differences in behavior between house mice and white-footed and deer mice such as foraging and hoarding food make the deer and white-footed harder to control. For this reason, loose-grain bait formulation or secured paraffin wax bait blocks may be more effective since they cannot be easily carried off. Cabins should be baited before being left unoccupied.

THE MEADOW VOLE
(Microtus pennsylvanicus)

The meadow vole, also called the field mouse, is found throughout Ohio. They have short brown fur with a gray or silver stomach. Their head is short and rounded with very small eyes and ears that are hidden by fur.

Meadow voles make extensive underground tunnels. Above ground, they make “runways” through the grass. These are easily seen even after snow melts. Their droppings are comparatively large, coiled and wet, unlike those of mice, which are small, slender and tapered.

Meadow voles are active both day and night, which makes them excellent prey for predators.

Life Cycle – The adult meadow vole is 3 to 5 inches in length. The adult meadow vole weighs between 3/4 to 2 1/2 ounces.

Meadow voles breed year round with most breeding activity taking place March through November. The gestation period for pregnant female meadow voles is about 21 days. They have 1 to 5 litters per year, and the litter size is from 1 to 11 young (usually 3 to 6). The meadow vole young are weaned from 14 to 21 days after birth.
Figure 18.10 Meadow Vole (Image courtesy of the Ohio Historical Society)

**Food** – The primary foods for meadow voles are grasses, weeds, shoots, tender twigs, and live bark.

**Habitat** – Meadow voles usually require dense grass cover and occasionally enter buildings at ground level. They are poor climbers. They cannot enter building like rats, house mice, white-footed or deer mice can. Meadow voles blunder into the buildings more by accident. Meadow voles are always restricted to building areas near ground level. They are sometimes found in stables and barns as hitchhikers in bales of hay recently removed from the field.

Meadow voles may also move from farm or uncultivated land into adjacent home lawns, gardens and landscaped areas. Here they make their presence known by chewing unsightly, well-defined surface runway systems. These systems are in lawns. The meadow vole creates them by digging shallow burrows in planting beds. They damage planting beds, girdle fruit trees, and feed on a variety of ornamentals.

**CONTROL AND MANAGEMENT OF THE MEADOW VOLE**

**Exclusion** – The best solution to the meadow vole problem is to rodent-proof buildings as one would for house mice. Use fine-mesh wire fencing or metal barriers. To protect vegetable gardens or fruit tree trunks from meadow vole feeding damage and prevent voles from falling into swimming pools, fine-mesh wire fencing or metal barriers (at least 12 inches high) can be used.

**Toxic Baiting** – In landscaped areas or backyard gardens, rodenticide baits can be used to control meadow voles. Tamper-resistant bait stations should be used for application of anticoagulant baits at ground level. These are placed along vole runways or nests to burrows. The same bait stations will also prove useful in controlling the presence of house mice and deer mice. Alternatively, seed baits and small pellet baits can be placed deep into the meadow vole’s nest and accessed burrows.
APPENDIX A
GLOSSARY

**ABSORPTION**—The movement of a chemical into plants, animals (including humans), and/or microorganisms.

**ACARICIDE**—A pesticide used to control mites and ticks. A miticide is an acaricide.

**ACTIVE INGREDIENT**—The chemical or chemicals in a pesticide responsible for killing, poisoning, or repelling the pest. Listed separately in the ingredient statement.

**ACUTE TOXICITY**—The capacity of a pesticide to cause injury within 24 hours following exposure. LD50 and LC50 are common indicators of the degree of acute toxicity. (See also chronic toxicity).

**ADJUVANT**—A substance added to a pesticide to improve its effectiveness or safety. Same as additive. Examples: penetrants, spreader-stickers, and wetting agents.

**ADSORPTION**—The process by which chemicals are held or bound to a surface by physical or chemical attraction. Clay and high organic soils tend to adsorb pesticides.

**AGGREGATION PHEROMONE**—See pheromone.

**AEROSOL**—A material stored in a container under pressure. Fine droplets are produced when the material dissolved in a liquid carrier is released into the air from the pressurized container.

**ALGAE**—Relatively simple plants that contain chlorophyll and are photosynthetic.

**ALGICIDE**—A pesticide used to kill or inhibit algae.

**ANTI-SIPHONING DEVICE**—a device attached to the filling hose that prevents backflow or back siphoning from a spray tank into a water source.

**ANTICOAGULANT**—A chemical that prevents normal blood clotting—the active ingredient in some rodenticides.

**ANTIDOTE**—A treatment used to counteract the effects of pesticide poisoning or some other poison in the body.

**ARACHNID**—A wingless arthropod with two body regions and four pairs of jointed legs. Spiders, ticks, and mites are in the class Arachnida.

**ARTHROPOD**—An invertebrate animal characterized by a jointed body and limbs and usually a hard body covering that is molted at intervals. For example, insects, mites, and crayfish are in the phylum Arthropoda.

**ATTRACTANT**—A substance or device that will lure pests to a trap or poison bait.

**AVICIDE**—A pesticide used to kill or repel birds. Birds are in the class Aves.

**BACTERIA**—Microscopic organisms, some of which are capable of producing diseases in plants and animals. Others are beneficial.

**BACTERICIDE**—Chemical used to control bacteria.

**BAIT**—A food or other substance used to attract a pest to a pesticide or to a trap.

**BARRIER APPLICATION**—Application of a pesticide in a strip alongside or around a structure, a portion of a structure, or any object.

**BENEFICIAL INSECT**—An insect that is useful or helpful to humans; usually insect parasites, predators, pollinators, etc.

**BIOLOGICAL CONTROL**—Control of pests using predators, parasites, and disease-causing organisms. May be naturally occurring or introduced.

**BIOMAGNIFICATION**—The process whereby one organism accumulates chemical residues in higher concentrations from organisms it consumes.

**BOTANICAL PESTICIDE**—A pesticide produced from chemicals found in plants. Examples are nicotine, pyrethrins, and strychnine.

**BRAND NAME**—The name or designation of a specific pesticide product or device made by a manufacturer or formulator; a marketing name.

**CALIBRATE, CALIBRATION OF EQUIPMENT, OR APPLICATION METHOD**—The measurement of dispersal or output and adjustments made to control the rate of dispersal of pesticides.

**CARBAMATES (N-methyl carbamates)**—A group of pesticides containing nitrogen, formulated as insecticides, fungicides and herbicides. The N-methyl carbamates are insecticides and inhibit cholinesterase in animals.

**CARCINOGENIC**—The ability of a substance or agent to induce malignant tumors (cancer).

**CARRIER**—An inert liquid, solid, or gas added to an active ingredient to make a pesticide dispense effectively. A carrier is also the material, usually water or oil, used to dilute the formulated product for application.

**CEPHALOTHORAX**—Combination of the head and thorax in a spider; eight legs are attached to the cephalothorax.

**CERCI**—Short appendages emerging from the abdominal segment of an insect (may help to identify an insect species).

**CERTIFIED APPLICATORS**—Individuals who are certified to use or supervise the use of any restricted-use pesticide covered by their certification.

**CHELICERAE**—Two short, needle-tipped appendages that are part of a spider’s mouthparts.

**CHEMICAL NAME**—The scientific name of the active ingredient(s) found in the formulated product. This complex name is derived from the chemical structure of the active ingredient.

**CHEMICAL CONTROL**—Pesticide application to kill pests.

**CHEMOSTERILANT**—A chemical compound capable of preventing animal reproduction.

**CHEMTREC**—The Chemical Transportation Emergency Center has a toll-free number (800-424-9300) that provides...
24-hour information for chemical emergencies such as a spill, leak, fire, or accident.

**CHLORINATED HYDROCARBON**—A pesticide containing chlorine, carbon, and hydrogen. Many are persistent in the environment. Examples: chlordane, DDT, methoxychlor. Few are used in structural pest management operations today.

**CHOLINESTERASE, ACETYLCHOLINESTERASE**—An enzyme in animals that helps regulate nerve impulses. This enzyme is depressed by N-methyl carbamate and organophosphate pesticides.

**CHRONIC TOXICITY**—The ability of a material to cause injury or illness (beyond 24 hours following exposure) from repeated, prolonged exposure to small amounts. (See also acute toxicity.)

**COMMERCIAL APPLICATOR**—A certified applicator who uses or supervises the use of any pesticide classified for restricted use for any purpose or on any property other than that producing an agricultural commodity.

**COMMON NAME**—A name given to a pesticide’s active ingredient by a recognized committee on pesticide nomenclature. Many pesticides are known by a number of trade or brand names, but each active ingredient has only one recognized common name.

**COMMUNITY**—The various populations of animal species (or plants) that exist together in an ecosystem. (See also population and ecosystem.)

**CONCENTRATION**—Refers to the amount of active ingredient in a given volume or weight of formulated product.

**CONTACT PESTICIDE**—A compound that causes death or injury to insects when it contacts them. It does not have to be ingested. Often used in reference to a spray applied directly on a pest.

**CONTAMINATION**—The presence of an unwanted substance (sometimes pesticides) in or on plants, animals, soil, water, air, or structures.

**CRAWSPACE**—A shallow space below the living quarters of at least a partially basementless house, normally enclosed by the foundation wall.

**CULTURAL CONTROL**—A pest control method that includes changing human habits—e.g., sanitation, work practices, cleaning and garbage pickup schedules, etc.

**DECONTAMINATE**—To remove or break down a pesticidal chemical from a surface or substance.

**DETECT ACTION LEVELS**—The maximum levels for defects such as the presence of insect fragments, mold, or rodent hairs in food products allowed by the Food and Drug Administration (FDA).

**DEGRADATION**—The process by which a chemical compound or pesticide is reduced to simpler compounds by the action of microorganisms, water, air, sunlight, or other agents. Degradation products are usually, but not always, less toxic than the original compound.

**DEPOSIT**—The amount of pesticide on treated surfaces after application.

**DERMAL TOXICITY**—The ability of a pesticide to cause acute illness or injury to a human or animal when absorbed through the skin. (See exposure route.)

**DESICCANT**—A type of pesticide that draws moisture or fluids from a pest, causing it to die. Certain desiccant dusts destroy the waxy outer coating that holds moisture within an insect’s body.

**DETOXIFY**—To render a pesticide’s active ingredient or other poisonous chemical harmless.

**DIAGNOSIS**—The positive identification of a problem and its cause.

**DILUENT**—Any liquid, gas, or solid material used to dilute or weaken a concentrated pesticide.

**DISINFECTANT**—A chemical or other agent that kills or inactivates disease-producing microorganisms. Chemicals used to clean or surface-sterilize inanimate objects.

**DOSE, DOSAGE**—Quantity, amount, or rate of pesticide applied to a given area or target.

**DRIFT**—The airborne movement of a pesticide spray or dust beyond the intended target area.

**DUST**—A finely ground, dry pesticide formulation containing a small amount of active ingredient and a large amount of inert carrier or diluent such as clay or talc.

**ECOSYSTEM**—The pest management unit. It includes a community (of populations) with the necessary physical (haborage, moisture, temperature), and biotic (food, hosts) supporting factors that allow an infestation of pests to persist.

**EMULSIFIABLE CONCENTRATE**—A pesticide formulation produced by mixing or suspending the active ingredient (the concentrate) and an emulsifying agent in a suitable carrier. When added to water, a milky emulsion is formed.

**EMULSIFYING AGENT (EMULSIFIER)**—A chemical that aids in the suspension of one liquid in another that normally would not mix together.

**EMULSION**—A mixture of two liquids that are not soluble in each other. One is suspended as very small droplets in the other with the aid of an emulsifying agent.

**ENCAPSULATED FORMULATION**—A pesticide formulation with the active ingredient enclosed in capsules of polyvinyl or other materials; principally used for slow release.

**ENDANGERED SPECIES**—A plant or animal species whose population is reduced to the extent that it is near extinction and that a federal agency has designated as being in danger of becoming extinct.

**ENTRY INTERVAL**—See re-entry interval.

**ENVIRONMENT**—All of our physical, chemical, and biological surroundings, such as climate, soil, water, and air, and all species of plants, animals, and microorganisms.

**ENVIRONMENTAL PROTECTION AGENCY OR EPA**—The federal agency responsible for ensuring the protection of humans and the environment from potentially adverse effects of pesticides.

**EPA ESTABLISHMENT NUMBER**—A number assigned to each pesticide production plant by the EPA. The number indicates the plant at which the pesticide product was produced and must appear on all labels of that product.
EPA REGISTRATION NUMBER—An identification number assigned to a pesticide product when the product is registered by the EPA for use. The number must appear on all labels for a particular product.

ERADICATION—The complete elimination of a (pest) population from a designated area.

EXOSKELETON—The external hardened covering or skeleton of an insect to which muscles are attached internally; periodically shed.

EXPOSURE ROUTE OR COMMON EXPOSURE ROUTE—The manner (dermal, oral, or inhalation/respiratory) by which a pesticide may enter an organism.

FIFRA—The Federal Insecticide, Fungicide, and Rodenticide Act; a federal law and its amendments that control pesticide registration and use.

FLASHING—Strips of aluminum, lead, tin, or copper that are worked into the slates or shingles around dormers, chimneys, and other rising parts to prevent leaking.

FLOWABLE—A pesticide formulation in which a very finely ground solid particle is suspended (not dissolved) in a liquid carrier.

FLUSHING AGENT—An inspection tool used to force insects from their hiding spots. Only by using a flushing agent can you determine if insects are hiding in areas physically impossible to see. Flushing agents can be applied with hand-held sprayers.

FOG TREATMENT—A fine mist of pesticide in aerosol-sized droplets (under 40 microns). Not a mist or gas. After propulsion, fog droplets fall to horizontal surfaces.

FORMULATION—The pesticide product as purchased, containing a mixture of one or more active ingredients, carriers (inert ingredients), and other additives making it easy to store, dilute, and apply.

FUMIGANT—A pesticide formulation that volatilizes, forming a toxic vapor or gas that kills in the gaseous state. Usually, it penetrates voids to kill pests.

FUNGICIDE—A chemical used to control fungi.

FUNGUS (plural, fungus)—A group of small, often microscopic, organisms in the plant kingdom that cause rot, mold and disease. Fungi need moisture or a damp environment (wood rots require at least 19 percent moisture). Fungi are extremely important in the diet of many insects.

GENERAL-USE (UNCLASSIFIED) PESTICIDE—a pesticide that can be purchased and used by the general public. (See also restricted-use pesticide.)

GENERAL TREATMENT—Application of a pesticide (either general-use or restricted-use) to broad expanses of surfaces such as walls, floors, and ceilings, or as an outside treatment.

GRANULE—A dry pesticide formulation. The active ingredient is either mixed with or coated onto an inert carrier to form a small, ready-to-use, low-concentrate particle that normally does not present a drift hazard. Pellets differ from granules only in their precise uniformity, larger size, and shape.

GROUNDWATER—Water sources located beneath the soil surface from which spring water, well water, etc., are obtained. (See also surface water.)

HARBORAGE—Any place or site that shelters and provides other elements (i.e., food, water) required for survival of a particular organism.

HAZARD—see risk.

HERBICIDE—A pesticide used to kill plants or inhibit plant growth.

HOLDFAST—Recurred teeth or ridges on the central mouthparts of ticks used to hold them in place while feeding on a host.

HOST—Any animal or plant on or in which another lives for nourishment, development, or protection.

IGR, INSECT GROWTH REGULATOR JUVENOID—A pesticide constructed to mimic insect hormones that control molting and the development of some insect systems affecting the change from immature to adult. (See juvenile hormone.)

INERT INGREDIENT—In a pesticide formulation, an inactive material without pesticidal activity.

INGREDIENT STATEMENT—In a pesticide formulation, the active ingredient and the total amount of inert ingredients in the formulation.

INHALATION—Taking a substance in through the lungs; breathing in. (See exposure route.)

INSECT GROWTH REGULATOR—see IGR.

INSECTICIDE—A pesticide used to manage or prevent damage caused by insects. Sometimes generalized to be synonymous with pesticide.

INSECTS, INSECTA—A class in the phylum Arthropoda characterized by a body composed of three segments (head, thorax; and abdomen) and three pairs of legs.

INSPECTION—To examine for pests, pest damage, other pest evidence, etc. (See monitoring.)

INTEGRATED PEST MANAGEMENT—see IPM.

IPM—Integrated pest management. A planned pest control program in which methods are integrated and used to keep pests from causing economic, health-related, or aesthetic injury. IPM includes reducing pests to a tolerable level. Pesticide application is not the primary control method but is an element of IPM—as are cultural and structural alterations. IPM programs emphasize communication, monitoring, inspection, and evaluation (keeping and using records).

JOIST—One of a series of parallel beams, usually 2 inches in thickness, used to support floor and ceiling loads, and supported in turn by larger beams, girders, bearing walls, or foundation.

JUVENILE HORMONE—A hormone produced by an insect that inhibits change or molting. As long as juvenile hormone is present, the insect does not develop into an adult but remains immature.

LABEL—All printed material attached to or on a pesticide container.

LABELING—The pesticide product label and other accompanying materials that contain directions that pesticide users are legally required to follow.

LARVA (plural larvae)—An early developmental stage of insects with complete metamorphosis. Insects hatch out of the egg as larvae before becoming pupae (resting stage), and then adults.

LC50—Lethal concentration. The concentration of a pesticide, usually in air or water, that kills 50 percent of a test population...
One pair of legs and usually one pair of wings are attached.

METATHORAX — The second segment of an insect's thorax. One pair of legs and usually one pair of wings are attached.

METAMORPHOSIS — A change in the shape, or form, of an animal. Usually used when referring to insect development.

METATHORAX — The third segment of an insect's thorax. One pair of legs and often one pair of wings are attached.

MICROBIAL DEGRADATION — Breakdown of a chemical by microorganisms.

MICROBIAL PESTICIDE — Bacteria, viruses, fungi, and other microorganisms used to control pests. Also called biortionals.

MICROORGANISM — An organism so small it can be seen only with the aid of a microscope.

MITICIDE — A pesticide used to control mites. (See acaricide.)

MODE OF ACTION — The way in which a pesticide exerts a toxic effect on the target plant or animal.

MOLLUSCID — A chemical used to control snails and slugs.

MOLT — Periodic shedding of the outer layer (e.g., an insect’s exoskeleton is shed periodically).

MONITORING — On-going surveillance. Monitoring includes inspection and record keeping. Monitoring records allows technicians to evaluate pest population suppression, identify infested or non-infested sites, and manage the progress of the management or control program.

NECROSIS — Death of plant or animal tissues that results in the formation of discolored, sunken, or necrotic (dead) areas.

NODE — Nodes are swollen segments found near the narrow connection between the thorax and abdomen of ant species. The nodes may be helpful in identifying ant species — most ant species have one node; others have two.

NON-RESIDUAL PESTICIDE — Pesticides applied to obtain effects only during the time of treatment.

NON-TARGET ORGANISM — Any plant or animal other than the intended target(s) of a pesticide application.

NYMPH — The developmental stage of insects with gradual metamorphosis that hatches from the egg. Nymphs become adults.

ORAL TOXICITY — The ability of a pesticide to cause injury or acute illness when taken by mouth. One of the common exposure routes.

ORGANOPHOSPHATES — A large group of pesticides that contain the element phosphorus and inhibit cholinesterase in animals.

PARASITE — A plant, animal, or microorganism living in, on, or with another living organism for the purpose of obtaining all or part of its food.

PATHOGEN — A disease-causing organism.

PERSONAL PROTECTIVE EQUIPMENT (PPE) — Devices and clothing intended to protect a person from exposure to pesticides. Includes such items as long-sleeved shirts, long trousers, coveralls, suitable hats, gloves, shoes, respirators, and other safety items as needed.

PEST MANAGEMENT — The reduction of pest populations to tolerable numbers by changing practices, making habitat or structural alterations, and carefully using pesticides to kill pests only when indicated.

PEST — An undesirable organism (plant, animal, bacterium, etc.); any organism that competes with people for food, feed, or fiber, causes structural damage, is a public health concern, reduces aesthetic qualities, or impedes industrial or recreational activities.

PESTICIDE — A chemical or other agent used to kill, repel, or otherwise control pests or to protect from a pest.

pH — A measure of the acidity/alkalinity of a liquid — acid below pH 7; basic or alkaline above pH 7 (up to 14).

PHEROMONE — A substance emitted by an animal to influence the behavior of other animals of the same species. Examples are sex pheromones (to attract mates) and aggregation pheromones (to keep members of the same species together in a group). Some pheromones are synthetically produced for use in insect traps.

PHOTOGRADATION — Breakdown of chemicals by the action of light.

PHYSICAL CONTROL — Habitat alteration or changing the infested physical structure — e.g., caulking holes, cracks, tightening around doors, windows, moisture reduction, ventilation, etc.

PHYTOTOXICITY — Injury to plants caused by a chemical or other agent.

POINT OF RUNOFF — The point at which a spray starts to run or drip from the surface to which it is applied.

POISON CONTROL CENTER — A local agency, generally a hospital, which has current information on the proper first aid techniques and antidotes for poisoning emergencies. Centers are listed in telephone directories.

POPULATION — Individuals of the same species. The populations in an area make up a community. (See ecosystem.)

PRECIPITATE — A solid substance that forms in a liquid and settles to the bottom of a container; a material that no longer remains in suspension.

PREDATOR — An animal that attacks, kills, and feeds on other animals. Examples of predaceous animals are hawks, owls, snakes, many insects, etc.

PROFESSIONAL — One who is able to make judgments based on training, experience, and an available data base.

PRONOTUM — The area just behind an insect’s head (i.e., the upper plate of the prothorax). In cockroaches it forms a shield that covers part of the head and mesothorax.

PROPELLANT — The inert ingredient in pressurized products that forces the active ingredient from the container.

PROTHORAX — The first segment of an insect’s thorax. One pair of legs is attached.
PUPA (plural pupae)—The developmental (resting) stage of insects with complete metamorphosis where major changes from the larval to the adult form occur.

RAFTER—One of a series of structural members of a roof designed to support roof loads. The rafters of a flat roof are sometimes called roof joists.

RATE OF APPLICATION—The amount of pesticide applied to a plant, animal, unit area, or surface; usually measured as per acre, per 1,000 square feet, per linear foot, or per cubic foot.

RE-ENTRY INTERVAL—The length of time following an application of a pesticide when entry into the treated area is restricted.

REGISTERED PESTICIDES—Pesticide products that have been registered by the Environmental Protection Agency for the uses listed on the label.

REPELLENT—A compound that keeps insects, rodents, birds, or other pests away from humans, plants, domestic animals, buildings, or other treated areas.

RESIDUAL PESTICIDE—A pesticide that continues to remain effective on a treated surface or area for an extended period following application.

RESIDUE—The pesticide active ingredient or its breakdown product(s) that remain in or on the target after treatment.

RESTRICTED-USE PESTICIDE—A pesticide that can be purchased and used only by certified applicators or persons under their direct supervision. A pesticide classified for restricted use under FIFRA, Section 3(d)(1)(C).

RISK—A probability that a given pesticide will have an adverse effect on humans or the environment in a given situation.

RODENTICIDE—A pesticide used to control rodents.

RUNOFF—The movement of water and associated materials on the soil surface. Runoff usually proceeds to bodies of surface water.

SCUTUM—Shield-like structure located near the front part of the mesothorax of an insect.

SOFFIT—The underside of an overhanging part or member (especially on the roof) of a building.

SIGNAL WORDS—Required word(s) that appear on every pesticide label to denote the relative toxicity of the product. Signal words are DANGER-POISON, DANGER, WARNING, and CAUTION.

SILL PLATE—A horizontal member anchored on top of a masonry wall.

SITE—Areas of pest infestation. Each site should be treated specifically or individually.

SOIL INJECTION—The placement of a pesticide below the surface of the soil; common application method for termiticides.

SOIL DRENCH—To soak or wet the ground surface with a pesticide. Large volumes of the pesticide mixture are usually needed to saturate the soil to any depth.

SOIL INCORPORATION—The mechanical mixing of a pesticide product with soil.

SOLUTION—A mixture of one or more substances in another substance (usually a liquid) in which all the ingredients are completely dissolved. Example: sugar in water.

SOLVENT—A liquid that will dissolve another substance (solid, liquid, or gas) to form a solution.

SPACE SPRAY—A pesticide that is applied as a fine spray or mist to a confined area.

SPOT TREATMENT—Application of a pesticide to limited areas where pests are likely to be found. A method used to avoid contact of pesticides with food, utensils, or people.

SPINNERETS—Short appendages near the anal opening of a spider from which spiders spin silk webbing.

STOMACH POISON—A pesticide that must be eaten by an animal to be effective; it will not kill on contact.

STRUCTURAL PEST MANAGEMENT—Management of pest infestations that are normally problems in buildings. Structural pest management involves reducing pest populations to tolerable numbers in and around homes, businesses, hospitals, and other structures. These include pests that make their habitat inside buildings and also those that invade buildings from outside habitats. These pests may cause aesthetic or economic/structural damage and/or be the source of health-related problems.

SURFACE WATER—Water on the earth’s surface: rivers, lakes, ponds, streams, etc. (See also groundwater.)

SUSPENSION—Pesticide mixtures consisting of fine particles dispersed or floating in a liquid, usually water or oil. Example: wettable powders in water.

TARGET—The plants, animals, structures, areas, or pests at which the pesticide or other control method is directed.

TECHNICAL MATERIAL—The pesticide active ingredient in pure form as it is manufactured by a chemical company. It is combined with inert ingredients or additives in formulations such as wettable powders, dusts, emulsifiable concentrates, or granules.

THORAX—The middle part of an insect’s body between the head and the abdomen. It is divided into three segments—the prothorax, mesothorax, and metathorax. A pair of legs is attached to each thoracic region.

THRESHOLD—A level of pest density. The number of pests observed, trapped, counted, etc., that could be tolerated without an economic loss or aesthetic injury. Pest thresholds in structural pest management may be site specific—for example, different numbers of cockroaches may be tolerated at different sites (e.g., hospitals and garbage rooms). A threshold may be set at zero (e.g., termites in a wooden structure, flies in an operatory).

TOLERABLE LEVELS OF PESTS—The presence of pests at certain levels is tolerable in many situations. Totally eliminating pests in certain areas is sometimes not achievable without major structural alterations, excessive control measures, unacceptable disruption, unacceptable cost, etc. Pest levels that depend on pest observations vary. The tolerable level in some situations will be zero (e.g., termites). Structural pest management programs usually have lower tolerable levels of pests than agricultural programs.

TOXIC—Poisonous to living organisms.

TOXICANT—A poisonous substance such as the active ingredient in a pesticide formulation.

TOXICITY—The ability of a pesticide to cause harmful, acute, delayed, or allergic effects. The degree or extent to which a chemical or substance is poisonous.
**TOXIN**—A naturally occurring poison produced by plants, animals, or microorganisms. Examples: the poison produced by the black widow spider, the venom produced by poisonous snakes, and the botulism toxin produced by bacteria.

**TRACKING PATCHES**—A non-toxic dust (clay, talc, or powdered limestone) placed in suspected rodent runways and used to detect rodent tracks and estimate the numbers of rodents present.

**TRACKING POWDER**—Diluted rodenticides in dust form. It is applied to areas where rodents live and travel and sticks to their feet and fur. The tracking powder kills rodents when they swallow it while grooming themselves.

**UNCLASSIFIED PESTICIDE**—See general-use pesticide.

**USE**—The performance of pesticide-related activities requiring certification include: application, mixing, loading, transport, storage, or handling after the manufacturing seal is broken; care and maintenance of application and handling equipment; and disposal of pesticides and their containers in accordance with label requirements. Uses not needing certification are: long-distance transport, long-term storage, and ultimate disposal.

**VAPOR PRESSURE**—The property that causes a chemical to evaporate. The higher the vapor pressure, the more volatile the chemical or the easier it will evaporate.

**VECTOR**—A carrier, an animal (e.g., insect, nematode, mite) that can carry and transmit a pathogen from one host to another.

**VERTEBRATE**—Animal characterized by a segmented backbone or spinal column.

**VIRUS**—Ultramicroscopic parasites composed of proteins. Viruses can multiply only in living tissues and cause many animal and plant diseases.

**VOLATILITY**—The degree to which a substance changes from a liquid or solid state to a gas at ordinary temperatures when exposed to air.

**WATER TABLE**—The upper level of the water-saturated zone in the ground.

**WETTABLE POWDER**—A dry pesticide formulation in powder form that forms a suspension when added to water.

**ZONE**—The management unit, an area of potential pest infestation made up of infested sites. Zones will contain pest food, water, and harborage. A kitchen-bathroom arrangement in adjoining apartments might make up a zone; a kitchen, storeroom, waiters’ station, and loading dock at a restaurant may make up another. Zones may also be established by eliminating areas with little likelihood of infestation and treating the remainder as a zone. A zone will be an ecosystem.

For the further definition of terms consult:

- Pesticide Applicator Core Training Manual, 825, Ohio Department of Agriculture.
- Region V Office of the EPA, Chicago, Ill.
- Ohio Department of Agriculture State Plan for Commercial and Private Applicators.
- Federal Agency Secretary’s Office (for federal employees using restricted pesticides in performance of official duties).
- Local, state, and national pest control associations.
# APPENDIX B
## PESTICIDES USED IN STRUCTURAL PEST MANAGEMENT

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Oral $LD_{50}$ (mg/kg)</th>
<th>Dermal $LD_{50}$ (mg/kg)</th>
<th>Signal Words</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INSECT ATTRACTANTS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>heptyl butyrate muscalure</td>
<td>$&gt;23,070$</td>
<td>$&gt;2,025$</td>
<td>Caution</td>
</tr>
<tr>
<td><strong>BOTANICALS AND PYRETHROID INSECTICIDES</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>allethrin</td>
<td>$680-1,000$</td>
<td>$&gt;11,200$</td>
<td>Caution</td>
</tr>
<tr>
<td>azadirachtin</td>
<td>$&gt;5,000$</td>
<td>$&gt;2,000$</td>
<td>Caution</td>
</tr>
<tr>
<td>bifenthrin</td>
<td>$54.5$</td>
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</tr>
<tr>
<td>bioresmethrin</td>
<td>$450-680$</td>
<td></td>
<td>Caution</td>
</tr>
<tr>
<td>cyfluthrin</td>
<td>$500-800$</td>
<td>$&gt;5,000$</td>
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</tr>
<tr>
<td>cypermethrin</td>
<td>$247$</td>
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<td>cyphenothrin</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>d-limonene</td>
<td>$310-419$</td>
<td></td>
<td>Warning/Caution</td>
</tr>
<tr>
<td>d-trans allethrin</td>
<td>$425-860$</td>
<td></td>
<td>Caution</td>
</tr>
<tr>
<td>deltamethrin</td>
<td>$129-139$</td>
<td>$&gt;2,000$</td>
<td>Warning</td>
</tr>
<tr>
<td>empenthrin</td>
<td>$1,680-2,280$</td>
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<td></td>
</tr>
<tr>
<td>esfenvalerate</td>
<td>$74-458$</td>
<td>$&gt;5,000$</td>
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<td>fenfluthrin</td>
<td>$85-120$</td>
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</tr>
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<td>fenothrin</td>
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</tr>
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<td>fenvalerate</td>
<td>$451$</td>
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</tr>
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<td>fluvalinate</td>
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<td>Warning</td>
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<tr>
<td>lambda-cyhalothrin</td>
<td>$19-79$</td>
<td>$1,293-1,507$</td>
<td>Warning</td>
</tr>
<tr>
<td>linalool</td>
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<td>Caution</td>
</tr>
<tr>
<td>permethrin</td>
<td>$2,000-&gt;4,000$</td>
<td>$&gt;4,000$</td>
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</tr>
<tr>
<td>phenothrin</td>
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<td>$&gt;2,000$</td>
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</tr>
<tr>
<td>pyrethrins, pyrethrum</td>
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<td>resmethrin</td>
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<td>$2,500-&gt;3,040$</td>
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</tr>
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<td>rotenone (derris)</td>
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</tr>
<tr>
<td>tetramethrin</td>
<td>$&gt;4,640$</td>
<td>$&gt;15,000$</td>
<td>Caution</td>
</tr>
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<td>tralomethrin</td>
<td>$99-3,000$</td>
<td>$&gt;2,000$</td>
<td>Warning/Caution</td>
</tr>
<tr>
<td><strong>CARBAMATE INSECTICIDES</strong></td>
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</tr>
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<td>bendiocarb</td>
<td>$46-156$</td>
<td>$566-800$</td>
<td>Warning/Caution</td>
</tr>
<tr>
<td>carbaryl</td>
<td>$307-986$</td>
<td>$&gt;500-4,000$</td>
<td>Caution</td>
</tr>
<tr>
<td>propoxur</td>
<td>$83-104$</td>
<td>$&gt;1,000-2,400$</td>
<td>Warning/Caution</td>
</tr>
<tr>
<td><strong>CHLORINATED HYDROCARBON INSECTICIDES</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dicofol</td>
<td>$575-1,331$</td>
<td>$1,000-1,230$</td>
<td>Caution</td>
</tr>
<tr>
<td><strong>INSECT GROWTH REGULATORS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chitin Inhibitors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>diflubenzuron</td>
<td>$4,640-&gt;10,000$</td>
<td>$&gt;4,640$</td>
<td>Caution</td>
</tr>
</tbody>
</table>
hexaflumuron \(>5,000\) \(>5,000\) Caution
iufenuron \(>2,000\) \(>2,000\) Caution

**Juvenoids**
hydroprene \(>5,100\) \(>5,100\) Caution
methoprene \(>34,600\) \(3,038\rightarrow\) \(3,500\) Caution
pyriproxyfen \(>5,000\) \(>2,000\) Caution

**FUMIGANTS (AVT = acute vapor toxicity)**
chloropicrin \(250\) Danger
methyl bromide \(\text{AVT} = 200 \text{ ppm}\) Danger
napthalene \(2,200\) Caution
paradichlorobenzene \(500-5,000\) \(>2,000\) Warning
phosphine \(\text{AVT} = 200 \text{ ppm}\) Danger
sulfuryl fluoride Danger

**INORGANIC INSECTICIDES**
borax, boric acid \(2,660-5,190\) Caution
diatomaceous earth Caution
precipitated silica Caution
sodium fluoride \(75-150 \text{ (to humans)}\) Danger

**MICROBIAL INSECTICIDES**
*Bacillus thuringiensis var. israelensis* Caution

**INSECTICIDAL BAIT TOXICANTS**
abamectin \(13.6\) \(>2,000\) Caution
hydramethylnon \(1,131\) \(>5,000\) Caution
sulfuramicid \(543\) Caution

**ORGANOPHOSPHATE INSECTICIDES**
acephate \(866-945\) \(>2,000\) Caution
chlorpyrifos \(82-245\) \(202-2,000\) Warning
chlorpyrifos-methyl \(941-3,733\) \(>2,000\) Warning
cythioate \(160\) \(>2,500\) Warning
diazinon \(300-400\) \(3,600\) Warning/Caution
dichlorvos, DDVP \(56-80\) \(75-107\) Danger
dimethoate \(28-500\) \(>150-1,150\) Warning
dioxathion \(19-176\) \(53-350\) Danger/Warning
disulfoton \(2-12\) \(6-25\) Danger
fenitrothion \(250-740\) \(200-> 3,000\) Warning
fenthion \(255-740\) \(1,680-2,830\) Warning
malathion \(885-2,800\) \(4,000-> 4,444\) Caution
methomyl \(17-24\) Caution
naled \(250-430\) \(800-1,100\) Danger
pirimiphos-methyl \(2,050\) \(>2,000-> 4,000\) Caution
propetamphos \(119\) \(2,825\) Warning/Caution
ronnel \(1,740\) \(1,000-2,000\) Caution
temephos \(1,000-13,000\) \(>4,000\) Caution
trichlorfon \(450-630\) \(>2,000\) Warning

**INSECT REPELLENTS**
R-874 \(8,500\) Caution
dee \(1,950-2,000\) \(10,000\) Caution
dibutyl phthalate \(12,000-> 20,000\) Caution
dimethyl phthalate \(6,900-8,200\) \(>4,000\) Warning
MGK 326 \(5,230-7,320\) \(9,400\) Caution
permethrin \(430-4,000\) \(>4,000\) Warning/Caution

**SOLVENTS (considered as active ingredients)**
petroleum distillates

**INSECTICIDE SYNERGISTS**
<table>
<thead>
<tr>
<th><strong>AVICIDES</strong></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>piperonyl butoxide</td>
<td>6,150-&gt; 7,500</td>
<td>&gt;7,950</td>
<td>Caution</td>
</tr>
<tr>
<td>MGK 264</td>
<td>2,800</td>
<td>&gt;9,000</td>
<td>Caution</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>RODENTICIDES</strong></th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Anticoagulants</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>brodifacoum</td>
<td>0.27</td>
<td>50</td>
<td>Caution</td>
</tr>
<tr>
<td>bromadiolone</td>
<td>1.13</td>
<td></td>
<td>Caution</td>
</tr>
<tr>
<td>chlorophacinone</td>
<td>20.5</td>
<td></td>
<td>Caution</td>
</tr>
<tr>
<td>difethialone</td>
<td>0.51-0.56</td>
<td></td>
<td>Caution</td>
</tr>
<tr>
<td>diphenacine</td>
<td>1.86-2.88</td>
<td></td>
<td>Caution</td>
</tr>
<tr>
<td>warfarin</td>
<td>1-186</td>
<td></td>
<td>Caution</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Nonanticoagulants</strong></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>bromethalin</td>
<td>2.0-5.9</td>
<td></td>
<td>Caution</td>
</tr>
<tr>
<td>cholecalciferol</td>
<td>40-50</td>
<td></td>
<td>Caution</td>
</tr>
<tr>
<td>strychnine</td>
<td>1-30</td>
<td></td>
<td>Danger</td>
</tr>
<tr>
<td>zinc phosphide</td>
<td>45</td>
<td></td>
<td>Danger/Caution</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>OTHER NEUROTRANSMITTER DISRUPTORS</strong></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>imidicloprid</td>
<td>1,858-2,591</td>
<td>&gt;2,000</td>
<td>Caution</td>
</tr>
<tr>
<td>fipronil</td>
<td>100</td>
<td>&gt;2,000</td>
<td>Warning</td>
</tr>
</tbody>
</table>


NOTE: Materials are listed by common chemical name; basic toxicity data (against laboratory animals), and signal words are generally listed on their product labels.