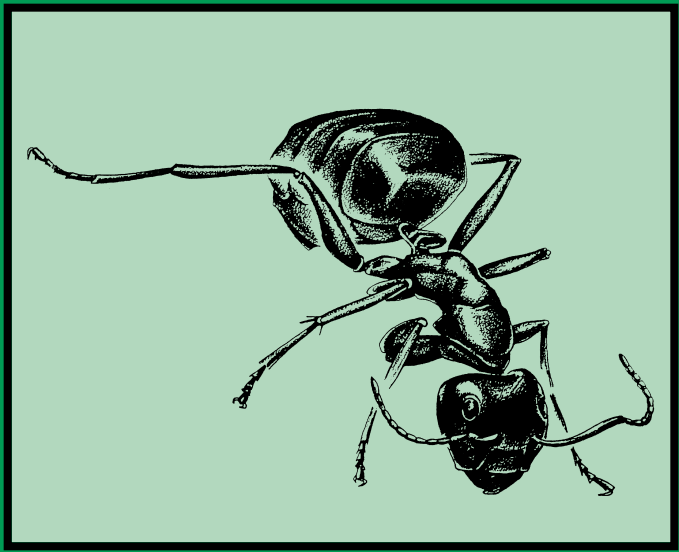
General Pest Management

A Guide for Commercial Applicators



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General Pest Management

A Guide for Commercial Applicators Category 7A

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Adapted from *Urban Integrated Pest Management, A Guide for Commercial Applicators,* written by Dr. Eugene Wood, Dept. of Entomology, University of Maryland; and Lawrence Pinto, Pinto & Associates; edited by Jann Cox, DUAL & Associates, Inc. Prepared for the U.S. Environmental Protection Agency Certification and Training Branch by DUAL & Associates, Arlington, Va., February 1991.

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In addition, we acknowledge the University of Florida for the use of several illustrations from the manual *General Household Pest Control, Applicator Training Manual*, University of Florida, 1994, Philip Koehler and William Kern, editors.[2] Special thanks go to Jane Medley of the University of Florida for arranging the use of the photographs.

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[1] The following illustrations were reproduced from *Truman's Scientific Guide to Pest Control*, 5th ed., copyright by Advanstar Communications, Inc: Figures 2.2, 2.3, 2.4, 4.1, 4.2, 5.1, 5.2, 5.3, 5.4, 6.15, 19.3, 19.9 (some original drawings by Arwin Provonsha, Purdue University).

[2] The following illustrations were reproduced from *General Household Pest Control, Applicator Training Manual*, with the permission of the University of Florida: Figures 2.1, 2.6, 6.1, 6.2, 6.4, 6.8, 6.9, 6.10, 6.11, 6.12, 6.14, 7.5, 7.8, 8.1, 8.2, 8.5, 8.6, 8.11, 8.12, 8.13, 8.19, 8.20, 8.23, 9.1, 10.1, 10.3, 10.4, 10.5, 11.1, 11.3, 11.4, 11.5, 11.7, 11.8, 11.9, 11.10, 12.1, 12.2, 12.3, 12.8, 12.9, 12.13, 12.14, 13.2, 13.3, 13.8, 14.1, 14.3, 14.4, 14.6, 14.9, 15.1, 15.2, 15.3, 15.4, 15.5, 15.6, 17.2, 17.3; the following color photographs in Appendix F: sawtoothed grain beetle, book louse, black carpet beetle, flea eggs and feces, bedbug; and all other color photographs in Appendix F which match the black and white figures already listed.

INTRODUCTION

How to Use This Manual

This manual contains the information needed to become a certified commercial applicator in Category 7A, General Pest Management. This manual is intended for use in combination with the *Pesticide Applicator Core Training Manual* (Extension Bulletin E-2195), available through the Michigan State University Bulletin Office. However, this manual would also be useful to anyone interested in learning more about general management of structure-infesting pests.

Category 7A—General Pest Management—covers the management and control of pests in homes, businesses, office buildings, hospitals, health care facilities, storage areas, industrial plants, schools and other structures. It discusses control and management of insects, other arthropods (such as spiders and ticks), and vertebrate pests (such as mice and rats) that may become problems inside buildings. The chapters contain basic scientific information as well as guidelines for practical solutions to pest control problems. The manual is divided into four sections:

- Section I—General Pest Management Information—covers general pest management and control including legalities, equipment use, and basic methods of pest control.
- Section II—Structure-infesting Pests—covers insects that commonly live inside buidings.
- Section III—Invading Pests—covers insects that invade buildings from outside habitats.
- Section IV—Rodents and Other Vertebrate Pests—covers vertebrate animals such as mice, rats, and raccoons that can become pests of structures.

The Category 7A certification exam will be based on information found in this booklet. Each chapter begins with a set of learning objectives that will help you focus on what you should get out of each chapter. The table of contents for each section of the manual is provided to help you identify important topics and understand how they relate to one another through the organization of headings and subheadings. As you prepare for the exam, read each chapter and answer the review questions located at the end. These questions are not on the certification exam. They are provided to help you prepare for the exam. Questions on the exam will pertain directly to the learning objectives.

The appendices and glossary, including an answer key (Appendix A), at the end of this manual provide supplemental information that will help you understand the topics covered in the chapters. Terms throughout the manual text that are bold and italicized can also be found in the glossary.

This certification manual benefits the applicator and the general public. By learning how to handle pesticides correctly, applicators will be able to protect themselves, others, and the environment from pesticide misuse. For more specific information on how to become a certified applicator in Michigan, refer to the beginning of the core manual (E-2195) or the Michigan Department of Agriculture's web site at: http:\\www.MDA.State.MI.US.

GENERAL PEST MANAGEMENT

A Guide for Commercial Applicators

Information about wood-destroying pests and core pesticide information are found in other manuals.

SECTION ONE
GENERAL PEST MANAGEMENT INFORMATION

SECTION TWO
STRUCTURE-INFESTING PESTS

SECTION THREE
INVADING PESTS

SECTION FOUR
RODENTS AND OTHER VERTEBRATE PESTS

SECTION 1

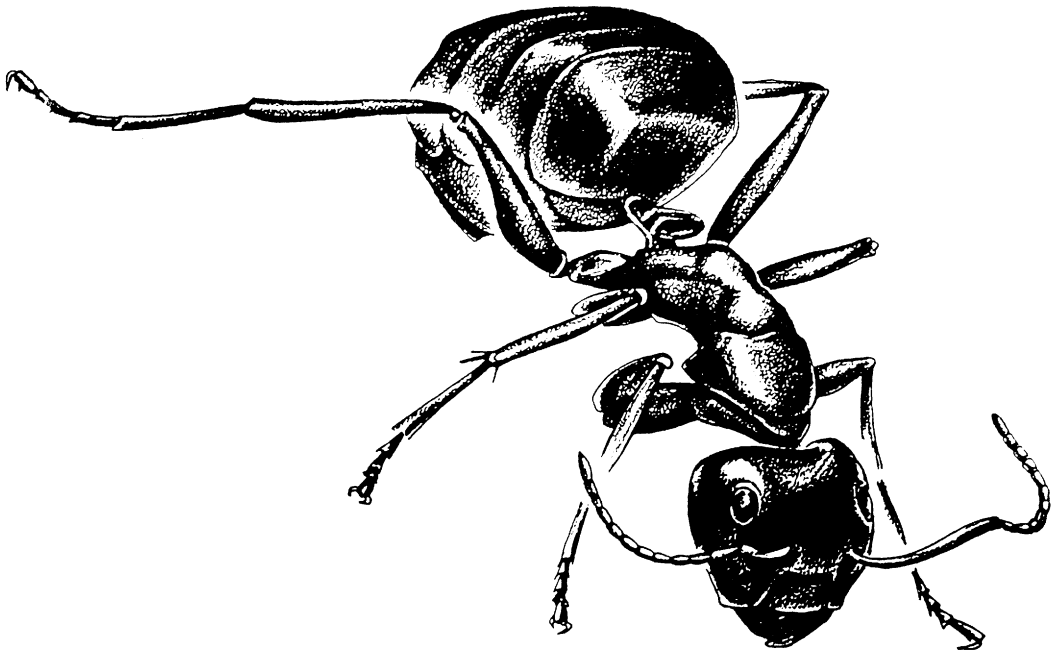
GENERAL PEST MANAGEMENT INFORMATION

This section provides basic information on the laws, methods, and equipment fundamental to structural pest management. Chapter 1 describes some state and federal laws affecting pesticide use with a particular focus on the State of Michigan's law, Regulation 637. Regulation 637 includes several regulations that directly affect Category 7A commercial applicators. Pesticide applicators must understand this law and their responsibilities to protect the public and the environment from pesticide misuse. Keep in mind that other state and federal laws also affect pesticide use; some of these are discussed in the Core Manual.

Chapter 2 describes the basic types of equipment needed for pest control operations. This information should be studied with regard to Regulation 637's rules about equipment safety and use. Safety is essential to every part of equipment use, and precautions must be taken to prevent off-target application of pesticides, to wear the appropriate personal protective equipment (PPE), and to use the pesticide consistent with the label instructions.

The basic pest management methods and approaches are outlined in Chapter 3. It is important for pest control technicians to realize that pesticide use may not be required in every situation. Pest control techniques that do not involve pesticides, such as removing or changing the pest's food and shelter, may control the pest to the client's satisfaction. A variety of integrated pest management (IPM) techniques that minimize the use of pesticides may also be worthwhile.

Finally, Chapter 4 discusses how the pest control approaches described in Chapter 3 can be adapted to control pests under certain circumstances that require special consideration. These include pest management in supermarkets, zoos/pet stores, and food-handling, health care, and computer facilities.



SECTION 1

CHAPTER 1

LEGALITIES OF GENERAL PEST MANAGEMENT

LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Understand why protecting the public and the environment from exposure to pesticides is the applicator's responsibility.
- Know the role of a technician working in the pest control industry.
- Understand the various state and federal laws that govern pesticide use, handling, and storage.
- Be able to explain the legal responsibilities of a pesticide applicator according to the rules of Regulation 637.
- Describe the elements that should be included in the basic training of a pest control technician.

Pest management can be complex. It is a matter of using the right technologies and requires special equipment and safety measures. To be successful, it must be effective and not adversely affect people or the environment. The number and variety of pesticides has increased and pesticide technicians need to know more about safety and proper use than ever before. For these reasons, among others, many state and federal laws and regulations have been adopted to help protect the public, the environment, and pesticide handlers from the possible adverse effects caused by pesticide use. In this chapter, you will learn about the state and federal laws that regulate pesticide applicators with a particular focus on commercial pesticide applicators certified in Category 7A—General Pest Management. Applicators certified in this category are responsible for pest management in and around structures including homes, schools, hospitals, businesses, warehouses, etc. It is important that Category 7A pesticide technicians understand and keep up-to-date with the laws that affect pesticide application inside or around buildings. Ignorance of the law is never an accepted excuse for a violation.

PROTECTION: THE APPLICATOR'S RESPONSIBILITY

Ultimately, responsibility for protecting the environment from the possible adverse effects of pesticide use rests on the pesticide applicator. Preserving the biological diversity of our planet by protecting the environment contributes to the overall quality of life. Each plant and animal is part of a complex food chain; break one of the links and others are adversely affected. One disappearing plant can take with it up to 30 other species that depend on it, including insects, higher animals and even other plants. Pest management technicians may see their normal work as unlikely to affect the environment, but spills and leaks during mixing, loading, and transporting, or incorrect disposal can lead to pesticides in ground or surface water or in the habitat of non-target organisms.

Commercial pest control operators often service national parks, schools, and other sensitive areas. Category 7A 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 environments. All efforts should be made to achieve pest management goals through minimal use of pesticides in and around buildings. When pesticides are used, they should be applied in a manner that will prevent human contact.

MORE THAN JUST PESTICIDE APPLICATION

Structural pest managers use many other activities to control pests besides pesticide application. These other practices increase the effectiveness of the control program and often reduce pesticide use or make such use a secondary operation of the program. In recognition of the many tasks that individuals in pest control must perform, the title ***technician*** is used in this manual to denote a pesticide applicator, a pest control operator, and other individuals with titles that refer to the job of suppressing or exterminating pests.

An important area addressed throughout the manual is communication. Pest management and control is a service. Technicians must not only know their job, they must also be able to communicate effectively with their clients. The technician should be able to explain the basic procedures to the client's satisfaction. The client should feel confident that the technician is able to meet their pest control needs safely and effectively. Also, there is information that must be communicated to the customer as required by the State of Michigan, (see Rule 12, Regulation 637).

STATE AND FEDERAL LAWS

The *Pesticide Applicator Core Training Manual* (E-2195) discusses federal and state laws that govern the handling and use of pesticides. Review the Core Manual and understand how laws and regulations affect pesticide practices and use. These laws include federal laws such as the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), Occupational Safety and Health Act (OSHA), and the Endangered Species Act. State laws include the Natural Resources and Environmental Protection Act, Regulation 636, Regulation 637, and the Michigan Occupational Safety and Health Act (MIOSHA). These are just some of the laws that affect commercial pesticide applicators. They are briefly described below. Only Regulation 637 is discussed in further detail because of its particular relevance to Category 7A. Refer to the Core Manual to learn more about other laws affecting pesticide use and for further details on laws discussed in this chapter. Pesticide technicians should keep up-to-date copies of the laws and review their contents periodically. Copies of these laws can be obtained from MDA regional offices.

Federal Laws

FIFRA—This is the basic federal law, administered by the Environmental Protection Agency (EPA), that regulates pesticides—their use, handling, storage, transportation, sale, disposal, etc. The Michigan Department of Agriculture (MDA) has a cooperative agreement with the EPA to enforce some provisions of FIFRA in Michigan. Some of the provisions of FIFRA are that the EPA must register all pesticides before they can be sold or used. The pesticides must be classified as either ***"general-use"*** or ***"restricted-use."*** General-use pesticides are those that can be purchased without restriction. Restricted-use pesticides are those that can be used only by (or under the direct supervision of) a certified applicator. FIFRA also stipulates that persons who misuse pesticides (in a way that is "inconsistent with the pesticide labeling") are subject to penalties.

OSHA—OSHA is administered by the U.S. Department of Labor (DOL). OSHA governs the record-keeping and reporting requirements of all work-related deaths, injuries, and illnesses of businesses with 10 or more workers.

Endangered Species Act—This act requires the U.S. EPA to ensure that endangered or threatened plant and animal species are protected from pesticides. This act requires *each pesticide label* to limit its use in areas where these species could be harmed. Category 7A applicators must consider the possibility that endangered or threatened species may be affected by pesticides applied in and around buildings. The Michigan Department of Natural Resources (MDNR) Land and Water Management Division administers the Michigan Endangered Species Act (Act 451, Part 365) and maintains the federal and state endangered or threatened species lists. Michigan applicators who want to be sure they are complying with the Act must take the initiative and consult with the MDNR to be sure that there are no endangered or threatened species in their area. One of the goals of pest management is to protect off-target plants and animals from pesticides, whether they are endangered or not.

State Laws

Natural Resources and Environmental Protection Act, Act No. 451, Part 83, Pesticide Control—This legislation gives the director of the MDA authority to register or certify private and commercial applicators and to prescribe standards for certification and registration. Category 7A applicators are considered ***commercial applicators.*** Commercial applicators can be divided into two subclasses:

Subclass A—Any person (including homeowners) who uses or supervises the use of restricted-use pesticides (RUPs) for a non-agricultural purpose.

Subclass B—Any person who either (1) applies pesticides other than ready-to-use pesticides in the course of his or her employment, or (2) applies a pesticide for a commercial purpose (for hire).

Ready-to-use pesticides are those used from the manufacturer's original container (aerosols, pump sprays, strips, baits) with no need to mix or load into application equipment.

Regulation 636 (Pesticide Applicators)—This establishes the types of certified applicators and expands the pesticide record-keeping requirements. All commercial applicators shall maintain records of pesticide use for a time period not less than the following:

General-use Pesticides: One year following application.

Restricted-use Pesticides: Three years following application.

All records shall contain the following:

- The name and concentration of the pesticide applied
- The amount of pesticide applied
- The target pest or purpose
- The date the pesticide was applied
- The address or location of pesticide application
- Where applicable, the method and rate of application

The records must be made available to the MDA upon request.

Michigan Occupational Safety and Health Act (MIOSHA)—The MIOSHA Right-to-Know act requires employers to:

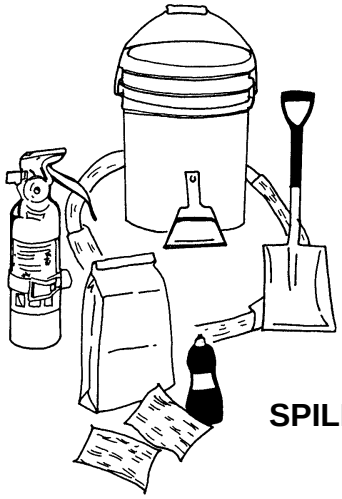
- Obtain and retain material safety data sheets (MSDS) on all hazardous chemicals (including pesticides) for employee review.
- Develop and implement a written employee training program.
- Ensure that all containers of hazardous materials are properly labeled.

REGULATION 637 (PESTICIDE USE) REQUIREMENTS

One of the pertinent state laws that Category 7A applicators must be familiar with and understand is *Regulation 637,* titled *Pesticide Use.* Regulation 637 establishes several legal standards for pesticide use. It requires that pesticides be used in a manner consistent with their labels, that applications be made in a manner that prevents off-target discharges of pesticides, and that pesticide application equipment be properly calibrated and in sound mechanical condition. The following discussion highlights some of the primary responsibilities of Category 7A pesticide applicators, according to Regulation 637. Obtain a copy of the entire regulation to understand the components of each rule and how your pest management business and practices must comply.

Rules 1 - 3 of Regulation 637 establish the definitions and terms used throughout the regulation. Rule 4 outlines several activities surrounding the safe and legal use of pesticides. It states that a pesticide application must be made in compliance with the following provisions:

- A pesticide must be used in a manner consistent with its label.
- Applications must be made so that off-target direct discharges are prevented.
- Pesticide application equipment will be in sound mechanical condition and be free of leaks and other defects that might cause a pesticide to be deposited off-target or in a way inconsistent with its label.
- Application equipment must be properly calibrated.
- Pesticide application or loading equipment that is designed to draw water must have an antisiphoning device.
- Any person who mixes, loads, or otherwise uses pesticides must have immediate access to a spill kit. The spill kit requirement does not apply to a person using single containers of use-dilution pesticides in a quantity less than 16 ounces.



SPILL KIT

- Applications shall not occur when conditions favor off-target drift of pesticides or prevent the proper deposition of pesticide to the target area.
- Before applying a pesticide, the applicator will identify any sensitive areas that are located adjacent to the target area and will use appropriate precautionary measures to prevent the direct discharge of pesticides to those areas.
- Each vehicle that is used to transport pesticides must have the following information printed on its exterior:
  - Name of the pesticide applicator firm
  - Business telephone number, address, or U.S. Department of Transportation census number of the applicator firm

Rule 5 of Regulation 637 establishes a registry of persons who must be notified before turfgrass or ornamental pesticide applications occur on adjacent and/or additional distance properties. At this time, structural pest control operators (7A) are not responsible for notifying persons on this list prior to a pesticide application.

Rule 6 of Regulation 637 requires that pesticide mixing and loading operations occur on a pad that complies with the following:

- The pad must be constructed with impervious materials.
- To prevent release of pesticides to the environment, the pad must be bermed, curbed, sloped, or designed to contain spills, leaks, releases, or other discharges generated during the mixing and loading of pesticides.
- Pesticides or pesticide-containing materials that are collected by the pad must be contained either by the pad itself or drained, pumped, or transferred to an additional impermeable, aboveground holding tank or reservoir until utilized or disposed of in compliance with applicable laws.
- The pad or holding tank/reservoir must be able to contain the amount of pesticide that could be discharged from mixing, loading, or application equipment during one minute of the mixing or loading operation.
- The mixing or loading of pesticides cannot occur unless a primary shutoff valve or switch is within immediate reach of the person who is engaged in the mixing or loading operation. (See the complete regulation for more details.)

The above specifications do not apply to pesticide applicators using only hand-held equipment.

Rule 7 of Regulation 637 requires that washing and rinsing of pesticide equipment be performed on a pad designed similarly to the mixing and loading pads. The requirements do not apply to applicators that use just hand-held equipment. (See the complete regulation for details.)

Regulation 637, Rule 8, discusses the most acceptable manner in which to handle excess pesticides and pesticide-containing material. Pesticide-containing materials are any materials that contain a mixture of active (pest controlling) or inactive (non-pest controlling) ingredients. These materials should be used in accordance with the label instructions. Both of the following uses of pesticides or pesticide-containing material are considered to be in accordance with label directions:

- Apply the pesticide or pesticide-containing material to a site that is specified on the label in a manner so that the total rate of application of the active ingredient is not more than the rate allowed on the label.
- Pesticide-containing materials may be used as diluents in subsequent mixtures of pesticides and diluents if the next application of such mixtures is in compliance with the above.

Refer to a complete copy of Regulation 637 for further details.

Regulation 637, Rule 9, Personal Protective Equipment (PPE), requires the applicator to follow label directions regarding PPE. This rule also sets minimum PPE requirements for commercial applicators. Unless otherwise directed by the pesticide product label, while performing pesticide tasks, applicators must wear:

- Long pants.
- Protective footwear.
- Long-sleeved clothing, (short-sleeved clothing may be worn if wash water or waterless soap is immediately available).
- Gloves impervious to the pesticide being used when the applicator's hands are likely to come in contact with the pesticide, unless a program is in place that offers comparable applicator protection.

Regulation 637, Rule 10, discusses pesticide drift considerations when making applications outdoors. Category 7A applicators need to keep in mind the air circulation patterns and ventilation systems inside buildings and how these may influence the movement of their pesticide application. The rule also specifies that if pesticide off-target drift is anticipated, due to the nature of the application, the applicator must use a drift management plan that includes specifications to secure the informed consent of residents in the affected area before making the application. For further specifications of the drift management plan, consult the regulation.

Regulation 637, Rule 11, Notification and Posting Requirements Part 4, pertains to persons who make insecticide applications to commercial buildings, health care facilities, licensed day-care centers, or schools. This part of the rule requires that upon completing insecticide applications, the applicator must provide a sign to be displayed in a readily observable place at the primary point of entry by the agent or representative of the building. The applicator must tell the building representative to keep the sign posted for not less than 48 hours after the

most recent insecticide application. The signs must comply with certain size minimums, and dating procedures, and contain certain illustrations. An illustration of a cloud symbol encompassing a house serves to inform the public that insecticides have been applied on the premises; this sign is available from the Michigan Pest Control Association (MPCA). Note the illustration on this page. See a complete copy of the regulation for additional posting details.

Regulation 637, Rule 12, Applicator Service Agreements, requires commercial pesticide applicators to enter into an oral or written service agreement with the customer or authorized agent. The agreement must specify:

1. The customer's consent to services.
2. The name, address, and telephone number of the company that provides the pesticide application services.
3. The approximate schedule and frequency of anticipated services.

Further, according to Rule 12, not later than at the time of each pesticide application, the commercial pesticide applicator must provide all of the following written information to the customer:

1. The name, address, and telephone number of the company providing the pesticide application service.
2. The full name of the applicator who is making the pesticide application.
3. A general description of the target pest or pests to be controlled.
4. A list of pesticides applied, including the common name of the active ingredient.
5. The time and date of the application.
6. Precautionary warnings that are pertinent to the protection of humans, animals, or the environment at the application site and that appear on the label of the pesticide(s) applied.

More information must be provided to the customer according to Regulation 637, Rule 12. Not later than at the time of the initial pesticide application, a commercial applicator must provide *risk and benefit information* to the customer. Risk and benefit information contains but is not limited to:

1. Definition of a pesticide.
2. A general description of how a pesticide works.
3. Why pesticides are used.
4. General toxicity information related to the following:
   - The type of compound used.
   - The environment where the pesticide is applied.
   - General exposure information.
   - The amount or rate of pesticide applied.
   - Proper pesticide applications in compliance with the label.
5. Common-sense precautionary measures to the customer regarding pesticides.
6. General information on the environmental fate of pesticides.
7. Instructions to the customer to discuss site preparation and precautionary measures with the pesticide applicator.
8. Instructions to the customer to consult with a physician if an unusual reaction occurs.

Rule 12 also specifies that the duration of a service contract cannot exceed 12 months unless either written notification of continuation of service is provided annually or unless the service agreement is a signed contract that specifies a definite period of time during which the contract is valid. The written notification of continuation of service must provide information to the customer on how to discontinue service.

Further, Rule 12 of Regulation 637 requires a commercial applicator to provide all of the following documents to the customer, if requested:

- Pesticide product labels
- Material safety data sheets (MSDS)
- Environmental Protection Agency fact sheets, if available
- A document that specifies the rate of application of the active ingredients of the products applied

Rule 13 prohibits misrepresentation of pesticide safety. Such claims or statements that would imply that the pesticide is recommended or endorsed by a federal or state agency, that the pesticide is "absolutely safe," or comparative statements of pesticide safety such as "contains all natural ingredients," "among the least toxic chemicals known," and "pollution approved" are strictly prohibited.

Rule 14 requires commercial applicator training in integrated pest management (IPM).

In order to make certain types of pesticide applications in schools, health care facilities and public buildings, Category 7A applicators must participate in a training program that includes the following IPM elements:

- Site evaluation, description, inspection and monitoring
- The concept of threshold levels
- The relationship between pest biology and pest management methods
- Pest population reduction (including mechanical, biological and chemical techniques) and pest prevention (including habitat modification)

- The development and implementation of an IPM program with consideration for reducing the possible impact of pesticide use on human health and the environment
- The evaluation of an IPM program to determine its effectiveness
- The record-keeping requirements of the IPM program

Rule 14 also specifies the elements that should be included in IPM programs applied to schools, public buildings, and health care facilities, and lists further details on evaluation and record-keeping requirements.

Rule 15 specifies the provisions regarding pesticide applications made in and around schools, including a provision that insecticide applications can not be made in school rooms unless the room(s) will be unoccupied for at least four hours (a longer time period may be required if specified by the product label). It is the pesticide applicator's responsibility to notify the school's building manager of the time period for reentry. The school district administrator or designee must provide written notification to parents before any pesticides are applied except in the case of emergencies, in which case notification is provided after the pesticide is applied.

Finally, Rule 16 establishes a registry of certified organic farms, and Rule 17 details the penalties for violation of local pesticide ordinances.

SUMMARY

A number of state and federal laws are designed to protect the public and the environment from the improper use of pesticides. It is the pest control technician's responsibility to understand and to comply with these laws. Category 7A technicians often apply pesticides in public areas. Therefore, they must be particularly sensitive about preventing contact between people and pesticides. Category 7A technicians should be trained in IPM and other methods that limit the use of pesticides while still achieving pest management goals. Regulation 637 outlines the details of this training along with other details pertaining to the safe and legal use of pesticides. Proper communication, notification, representation, and record keeping are essential whenever pesticides are used.

SECTION 1 CHAPTER 1

Review Questions

Chapter 1: Legalities of General Pest Management

Write the answers to the following questions and then check your answers with those in Appendix A in the back of this manual.

1. To control pests of structures, pesticide application is the only means for suppressing pests.
   A. True
   B. False

2. When technicians use other practices in addition to pesticide use for controlling pests:
   A. It may decrease the effectiveness of the control program.
   B. These practices often reduce pesticide use or make such use a secondary operation of the program.
   C. It is not a legal procedure.
   D. They must describe these tactics in writing for the customer.

3. The title ***technician*** is used in this manual to denote:
   A. A pesticide applicator.
   B. A pest control operator.
   C. Individuals with the job of suppressing or exterminating pests.
   D. All of the above.

4. Which Michigan regulation requires that pesticide applications be made in a manner that prevents off-target discharges of pesticides, and that pesticide application equipment be properly calibrated and in sound mechanical condition?
   A. Regulation 636
   B. Regulation 637
   C. FIFRA
   D. Natural Resources and Environmental Protection Act
   E. OSHA

5. Which Michigan legislation gives the MDA authority to certify commercial applicators and to prescribe standards for certification?
   A. Regulation 636
   B. Regulation 637
   C. FIFRA
   D. Natural Resources and Environmental Protection Act
   E. OSHA

6. Which federal legislation specifies that all pesticides be classified as either general-use or restricted-use?
   A. Regulation 636
   B. Regulation 637
   C. FIFRA
   D. Natural Resources and Environmental Protection Act
   E. OSHA

7. Which Michigan legislation establishes the types of certified applicators and expands the pesticide record-keeping requirements?
   A. Regulation 636
   B. Regulation 637
   C. FIFRA
   D. Natural Resources and Environmental Protection Act
   E. OSHA

8. Structural pest managers do not have to concern themselves with the possibility of harming endangered species.
   A. True
   B. False

9. In Michigan, a vehicle used to transport pesticides for a pesticide application business must:
   A. Be yellow or red.
   B. Have the name of the pesticide(s) being carried posted in an appropriate location in the vehicle.
   C. Have the name of the pesticide applicator firm and the business phone number printed on the exterior.
   D. Be registered with the MDA and the MDEQ.

10. In Michigan, commercial pesticide applicators must provide their customer written information in the Applicator Service Agreement including:

    A. The time and date of application.
    B. A general description of the target pest or pests to be controlled.
    C. A list of pesticides applied.
    D. All of the above.

11. Describe what type of pesticide information should be a part of the risk and benefit information provided to customers.

12. If requested, a commercial pesticide applicator must provide the customer with pesticide product labels and MSDS sheets.

    A. True
    B. False

13. Pesticide drift is not a concern to Category 7A applicators.

    A. True
    B. False

14. Notification and posting requirements include:

    A. Posting a sign for at least 48 hours after insecticide application.
    B. Posting a sign for at least 24 hours after insecticide application.
    C. The sign must comply with certain size minimums, and dating procedures, and contain certain illustrations.
    D. A & C
    E. B & C

15. List the minimum PPE requirements for commercial applicators.

16. Commercial pesticide applicators may represent pesticides as being endorsed by federal or state agencies.

    A. True
    B. False

17. List the elements that should be included in IPM training of commercial applicators.

18. What is the time interval for reentry after insecticides have been applied in a school room?

    A. A minimum of 4 hours
    B. A minimum of 6 hours
    C. It depends on the product label
    D. A & C
    E. B & C

SECTION 1

CHAPTER 2

USING EQUIPMENT IN GENERAL PEST MANAGEMENT

LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Know the basic types of pest management equipment and how they function.
- Know the benefits and limitations of pesticide application equipment.
- Know how to calibrate structural pesticide application equipment and why it is important.
- Understand how safety is part of every phase of equipment use.
- Know how to select the proper tool for a specific job.
- Be familiar with equipment maintenance to ensure safe, economical, and efficient use.

The most important part of a pest management program is the ability of a technician to use his knowledge of pest management along with well cared-for equipment and good supplies. A successful pest management program includes regular cleaning, calibration, and repair of tools; time, training, and planning are required to achieve the desired level of pest control.

EQUIPMENT FOR CONDUCTING PEST CONTROL INSPECTIONS

The inspection is the most critical phase of any pest management operation. To be effective in solving pest problems, you must correctly identify the pest, the locations and extent of the pest infestation, and the structural and/or environmental conditions encouraging pest problems. Therefore, professional pest management programs begin with professional inspections.

Equipment is necessary for conducting professional inspections and to enable you to gain access to structural areas and equipment voids to apply a treatment, if necessary.

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 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 to you and the customer the overall effectiveness of the control program.

Traps are available that incorporate German cockroach ***pheromones*** (i.e., a chemical substance produced by an insect of the same species that will attract them 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.

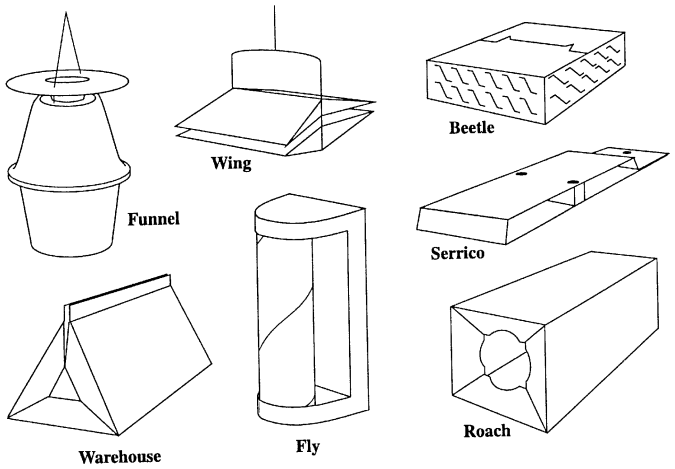


Figure 2-1. Several styles of pheromone traps are available, depending on the type of pest and on the location being monitored.

Flushing Agents

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

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 allows you to disassemble various inspection plates, ventilation grills, and access panels for inspection or treatment purposes.

Inspection Diagram, Inspection Reports, and Building Plans

Inspection diagrams giving an overview of the structure and surrounding buildings and areas are often helpful. In some cases, inspection diagrams need only be an outline of the building and its surrounding environment. Such an overview often helps you see the big picture and thus to consider all the factors inside and outside the structure that may affect the pest problem. Diagrams also are invaluable in helping recall details at a later date.

Inspection reports should list the specific pests present, the extent of the infestation, the control tools and chemicals to be used, structural deficiencies contributing to the pest problem, and so on.

For pest management operations in large or complex buildings (hospitals, high-rise condominiums, schools, etc.), **building plans** enable you to visualize floors and rooms above, below, and on all sides of problem areas. Knowing where the utility lines, heating/cooling ducts, shaft connections, pipe chases, and so on are located helps to pinpoint warm and humid areas within the building. This, in turn, can aid in identifying the high-activity areas of insects that require such environments (e.g., pharaoh ants, cockroaches, silverfish, and others). Building plans are also valuable for determining entry points and migration paths of pests from one part of the building to another. Finally, building plans can serve as a checklist to organize large pest management programs and help to ensure that all pertinent areas of the building complex receive attention.

Miscellaneous Inspection Equipment

Where permitted, **cameras** are useful tools for documenting situations and building conditions that need to be corrected. A **ladder** should be kept on the truck to enable you to inspect above suspended ceilings, cathedral ceilings, and outdoor roof areas. Never use a customer's chair or ladder.

Moisture meters and sound detection devices may be useful when inspecting for wood-destroying insects. Many wood-infesting pests seek wood or structural environments with high levels of moisture and humidity. The sound devices can help you detect the sounds of the pest working inside wooden areas.

EQUIPMENT FOR APPLYING PESTICIDES

Regardless of how well trained and knowledgeable a pest management professional may be, effective pest management cannot be achieved unless the professional is backed up with high-quality and dependable equipment. It is essential to know how to choose equipment best suited to each job and how to use it properly and safely to obtain the best results.

Keep in mind that there are many types of pest management equipment, and each type may have many models. This chapter focuses only on the basic models of each equipment group. New equipment technology and improvements to existing equipment are on-going, so even well equipped professionals need to regularly reexamine equipment to benefit by new developments. To keep up-to-date, regularly review current trade magazines and equipment brochures, attend educational con-

ferences and seminars, and visit and talk with local pest management suppliers. These sources of information are invaluable to today's pest control operator.

SPRAYERS

Sprayers vary from the hand-pumped flit gun with a tank capacity of as little as one cup to large hydraulic machines powered by gasoline engines and with tanks that can hold several hundred gallons of pesticide formulation. All sprayers have basic characteristics in common. There is usually a tank, a device to pressurize the liquid, a delivery line leading to a valve, and another delivery line leading from the valve to a nozzle. All other items found on any sprayer, whether simple or complex, are merely accessories and are incidental to this basic design.

Hand-held Compressed-air Sprayers

The small (1- or 2-gallon) stainless steel spray tank is the workhorse of the pest control industry. It is the tool most familiar to pest control technicians. Nevertheless, the general trend in structural pest management seems to be moving away from the sprayers as the mainstay of insect control equipment. More emphasis is being put on monitoring, baiting, and various non-chemical control techniques, and sprayer technology is evolving into devices designed for much more precise applications.

The hand-held compressed-air sprayer is used in many different ways. In pest management, the spray tank is used to apply a flushing agent or a residual pesticide. Depending on the nozzle selection, it applies various spray patterns; and depending on the amount of pumping, it delivers the pesticide under high or low pressure. A thorough understanding of the compressed-air sprayer—its basic construction, how it works, how to maintain it, and how to make repairs—can save time and money, and prevent misapplication.

Components. There are three major parts to the compressed air sprayer:

1. Tank.
2. Pump unit.
3. Applicator wand and hose.

The **tank** forms the body of the sprayer. Tank capacities range from ½ gallon to 3 gallons. Most professional tanks are made of stainless steel to resist the corrosive nature of many pesticide formulations. The tank serves two purposes: first, it is the reservoir for the spray mixture, and secondly, it acts as a pressure chamber. A **discharge tube** is 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** and various soft **gaskets** and **valves**. The pump unit is hand-operated to generate air pressure inside the tank.

The **applicator wand** is made up of the **valve trigge**r and the **nozzle,** and it is connected to the tank via a synthetic rubber (usually neoprene) **hose** that acts as the delivery tube from the tank to the applicator wand. Some

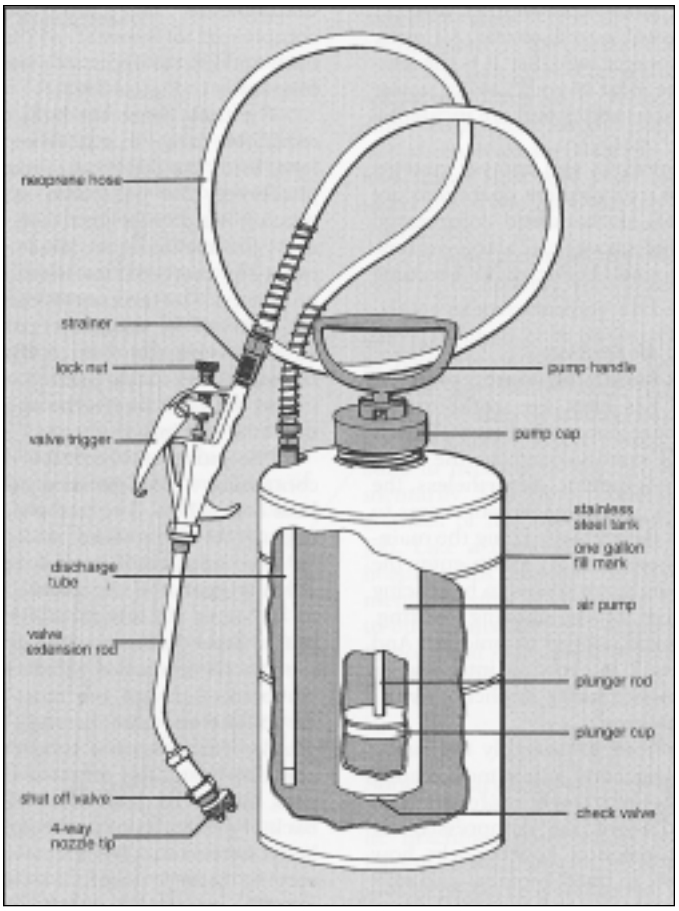


Figure 2-2. The major parts of a compressed-air sprayer (Provonsha).

wands are a stubby-nose design, but 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.

The **nozzle** is the smallest component on the sprayer, but it plays a very large role in proper pesticide application. Much of the effectiveness of a pesticide application depends on the proper functioning of the nozzle. Nozzle tips are designed to give specific shapes of spray at a set pressure. Most nozzles on the handheld sprayer offer a four-way multi-tip that can produce two different **pin-stream** spray patterns and two different **flat-fan** spray patterns. The applicator can easily and quickly change from a pin stream to a fan spray by rotating the tip.

Pin-stream nozzles produce solid streams of spray and are used to spray insecticides into various cracks and crevices. When set for fine spray, a stream is produced that can splash back from all but the widest cracks. Specialized nozzles are available with one pin-stream orifice adapted to the use of a plastic or metal **crack and crevice extension tube.** This is extremely useful because it permits the professional to apply pesticide directly into cracks and crevices with little worry of spilling or splashing pesticide on surrounding surfaces.

Flat-fan nozzles produce a fan-type spray pattern. These patterns provide an even coat of spray on flat sur-

faces, such as walls, and may also be used to apply pesticide into a crack wherever there is room enough for such application. Recognize that liquid dispersed into a crack using a fan pattern usually will not penetrate as deeply as when applied as a pin stream. Commonly on multi-tip nozzles, the smaller fan opening produces an 80 degree fine-fan spray pattern: the larger orifice produces 50 degree coarse-fan spray pattern. The coarse-fan orifice delivers more than twice as much spray per minute as the fine-fan orifice (see Table 2-1).

Table 2-1. The amount of spray delivered from a sprayer, depending on the nozzle orifice selected.

Pattern	Spray Angle	Oz of spray/minute @ 20 psi
Coarse fan	50 degrees	14.08
Fine fan	80 degrees	6.40
Broad pin stream	Straight	8.96
Fine pin stream	Straight	4.48
Crack & crevice straw	Straight	3.84
Aerosol-tip straw	Straight	7.04

Sprayer software is the various soft gaskets and valves contained within the application wand and pump unit. This software is critically important to the proper functioning of the sprayer. If sprayer software becomes worn, broken, or improperly installed, the sprayer will malfunction or constantly leak. Inspect sprayer software regularly and replace worn parts immediately.

Pressure. Spray tank air pressure varies according to the amount of air pumped into the tank. Pressure gauges can be attached to spray tanks. Low pressure is usually recommended for spray application inside structures. Constant use of high pressure with compressed-air sprayers sets up the possibility of overuse and misapplication. It causes part of the sprayed liquid to break into droplets as soon as it exits the nozzle; this wastes material, which can drift onto non-target surfaces. High pressure also causes splash back on surfaces or quickly traps air in crevices and keeps the pesticide from entering small spaces.

Establishing and maintaining **correct pressure** in the sprayer are important for obtaining good insect control and for safety. Keep in mind the following:

- Sprayer pressure affects the amount of insecticide applied and the type of pesticide coverage. Too much or too little pressure often causes spotty and uneven coverage, which results in poor insect control.
- High pressure is seldom necessary. Furthermore, excessive pressure may increase the hazards both to the applicator and to the public because of the possibility of hoses bursting under pressure. Also, insecticide particles at high pressures tend to bounce off the target surface. This is wasteful and dangerous—the pesticide may drift onto other people, objects, food, or food preparation surfaces.
- Continual excessive pressure on the sprayer causes premature wear and possible damage to the sprayer software.
- Some insecticide labels dictate the particular pressure appropriate for applications against specific pests.
- Always wear the appropriate personal protective equipment (PPE) as specified by the label and/or required by Regulation 637.

Sprayers should be equipped with a **pressure gauge.** The gauge allows the applicator to control and monitor the pressure in the tank at all times. This is important not only to prevent using excessively high pressures but also to monitor the pressure drop in the tank when the pesticide is being sprayed.

The correct pressure for the sprayer varies according to the type of insecticide application. For example, for crack and crevice treatments, pressures of less than 10 psi are most effective. Achieving pressures in this range requires only two to four strokes of the pump handle with a full 1-gallon sprayer.

General and spot treatments are most often performed using either the fine-fan or coarse-fan nozzle openings. A general, effective operating pressure for fan spray applications is between 20 and 25 psi. This pressure produces a uniform spray pattern. Fine-fan applications at this pressure include flea treatments on carpeting; coarse-fan applications include treating along outside foundation walls. To achieve 20 to 25 psi on a full 1-gallon sprayer requires between nine and eleven strokes of the pump handle.

Routine Sprayer Use. Proper routine use of the sprayer is critical for effective insect control and safety, and for keeping the sprayer in good working order. The following discussion provides key basics for effective and safe daily use of the sprayer. Familiarize yourself with your equipment and be prepared to repair it.

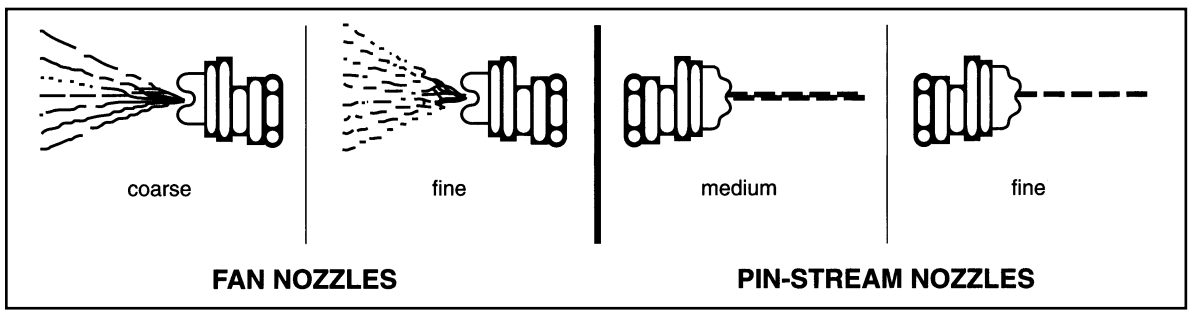


Figure 2-3. The spray patterns produced by the fan and pin-stream orifices on a four-way nozzle tip.

Correct **filling of the sprayer** is important to achieve a good mixture of water and insecticide. When filling the sprayer, follow these general rules:

- At the beginning of each workday, fill the sprayer with a little water and run a check to see that all components are working properly. This ensures safety, eliminates downtime, and prevents potential accidents.
- Never place the pump unit of the sprayer on the ground—it will collect dust, dirt, and possible contaminants that may clog the sprayer. Also, the pump may leave undesirable pesticide residue on the floor.
- When filling the sprayer, use clean water; allow the faucet to run for several seconds before collecting.
- Unless otherwise directed by the pesticide label, mix insecticide concentrates into the sprayer by first filling the tank about one-quarter full with cool water, then adding the concentrate, and then adding the remaining water.
- Never use warm water to mix sprays. Warm water helps break down pesticides, creates droplets that easily float, and increases a pesticide's odor.
- Fill the tank to only $^3/_4$ full of its total capacity. Most sprayers will have a 1-gallon indentation mark on the tank. The remaining 25 percent of space is used to build up air pressure.
- As emphasized in the Core Manual, always wear the appropriate PPE when working with pesticides. Always use safety glasses or goggles when treating areas above the head or close to the face.

When **using the sprayer** during the course of your workday:

- Always release the pressure from the sprayer if it is not used for an hour or more (e.g., over lunch). Hoses and gaskets deteriorate if insecticides are left in a sprayer under pressure for prolonged periods.
- If using different insecticide formulations (e.g., wettable powders, encapsulated pesticide, emulsions, etc.), use a separate sprayer for each type of pesticide. If not thoroughly cleaned when switching between a wettable powder and an emulsion, the sprayer may become clogged. Moreover, some insecticides, such as encapsulated formulations, require use of a large-mesh filter.
- Never pick up or carry the sprayer by the hose—this will stress and eventually cause breaks in the hose.
- Ensure that the supporting springs at both ends of the hose are always in place to prevent crimping and breakage of the hose.
- Never leave a sprayer in a vehicle for prolonged periods (e.g., overnight) in freezing temperatures. Severe damage to the tank, hose, and application wand can result.
- Keep a **sprayer repair ki**t readily available.
- Give special care to nozzles that become clogged. Nozzle tips are usually made of brass, a relatively soft metal that allows tips to be easily damaged. Never use metal objects to clean the nozzle. Unclog a nozzle either by back-flushing with water or by using a soft- bristle brush.
- Always attempt to calculate the amount of spray needed for the day's work schedule to avoid having material left at the end of the day. This precaution saves on chemical costs and eliminates the need to dispose of and/or store insecticides. Ideally, all insecticides should be used up on the job without over applying.
- Use the safety locknut, if there is one on the spray unit. When tightened, the locknut prevents the trigger from being accidentally activated and discharging pesticides.
- At the end of each workday, release the pressure and rinse the sprayer with water, especially the hose. Always empty liquid from the hose: hold the nozzle high and squeeze the trigger to drain the hose. If this is not done, liquid from the last use remains; it will be applied first at the next use, regardless of any new spray mix in the tank.
- Clean the sprayer on a regular schedule.

Backpack Sprayers

Backpack sprayers or knapsack sprayers are also commonly used in pest management operations, although not to the extent of the 1-gallon hand-held sprayer. Tank capacities usually range between 2 and 5 gallons. They are designed for continuous spraying of large areas.

Backpack sprayers are commonly used for applying herbicides and/or insecticides on lawns, along fences and building perimeters, and so forth. They may also be used for indoor pesticide and disinfectant spray applications, such as in large commercial food facilities and warehouses.

Most backpack sprayers use a specialized hand-operated lever to prime a piston pump to pressurize the sprayer. Depending on the model, pressures up to 150 psi can be generated, although working pressure on most is usually between 40 and 75 psi.

Because backpack sprayers are not the choice for precision applications using low pressures (such as crack and crevice applications), only two types of nozzle openings are usually available—flood jets and cone nozzles.

The cleaning and maintenance of backpack sprayers are similar in principle to those described for the hand-held sprayer. Consult the owner's manual for specific instructions.

Power Sprayers

As their name implies, power sprayers use electric or gasoline engines to pump liquid insecticides from a relatively large tank, usually over 100 gallons. The liquid is discharged through a $^3/_8$- to $^1/_2$-inch hose of sufficient length to reach from the pump to the application site. Power sprayers are generally used for one of two types of structural pest control: (1) controlling termites, and (2) spraying building perimeters and lawns.

Spraying outside also treats other types of outside pests (e.g., ticks, crickets, millipedes, and other miscellaneous invaders). Here too, low pressure is more effective than high pressure because the pesticide will not blast away the surface dust or soil and runoff. Low pressure allows for a more careful application, better soaking action, and better penetration through short grass.

Special attention should be paid to the hoses of power sprayers—both in the quality and points of wear. Wear or cuts cause hoses to burst. Shut-off valves must be in good working order. Be prepared and carry equipment (e.g., spill pad) to take care of spills in the service truck.

EQUIPMENT CALIBRATION

Why Calibrate Spraying Equipment?

Calibration is the process of measuring and adjusting the amount of pesticide your equipment will apply to a specific area. In structural pest management, much is up to the judgment of technicians. A pest control technician should know that the proper dosage of pesticide is being applied. Without accurate calibration of sprayers, the amount of pesticide delivered will be incorrect. Overdosage will contaminate the spray area or result in runoff. Less than recommended dosage might fail to control the pest. Technicians need to look regularly at the output of their equipment. Flow meters are very helpful to let the technician know the output of the sprayer over time.

- It is estimated that 60 percent of sprayers have a calibration error up to 10 percent.
- A large percentage of sprayers have greater than 10 percent variation in discharge from individual nozzles or tips.
- Application methods used by applicators vary, depending on pressure, nozzle tip, etc.
- Soil types and types of soil cover (grass, mulch, gravel) can influence the rate of pesticides a technician applies.

Manufacturers' instructions, university extension training meetings, label instructions and company policy should be considered and used to calibrate sprayers.

How to Calibrate Sprayers

Calibration does not have to be difficult. It can be accomplished by knowing:

1. How much spray mixture your sprayer applies per unit area.

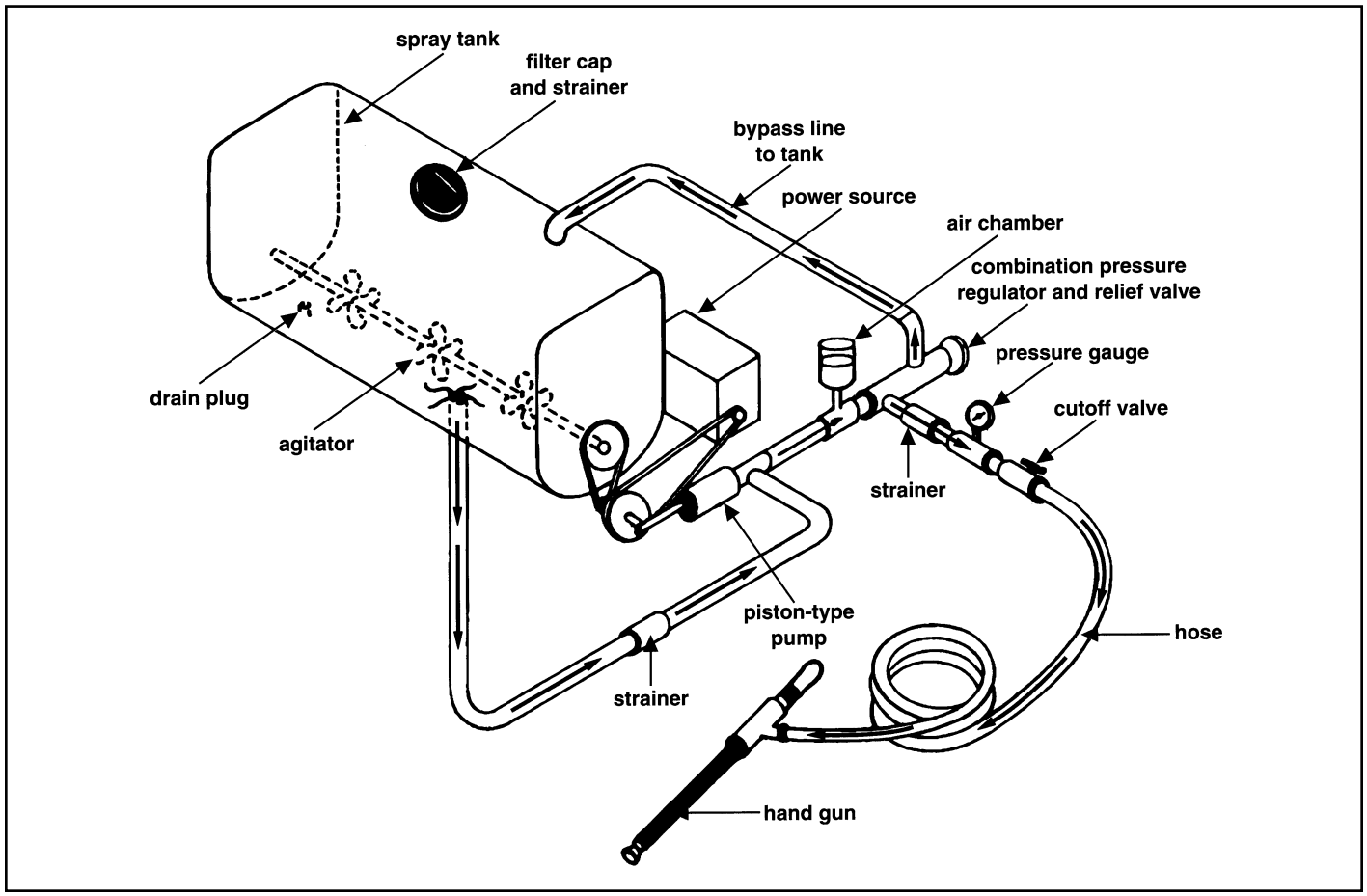


Figure 2-4. A schematic illustration of a simple power rig.

2. How much area you can spray per tank.
3. The recommended rate of pesticide application as specified by the label.
4. The amount of pesticide product to add to the spray tank.

The amount of spray applied per unit area is determined by the **nozzle flow rate.** The flow rate through a nozzle varies with the nozzle pressure and the size of the nozzle tip (see Table 2-1). Increasing the pressure or using a nozzle tip with a larger opening will increase the flow rate.

Increasing pressure will not, however, give you a proportional increase in flow rate. For example, doubling the pressure will not double the flow rate; you must increase the pressure fourfold to double the flow rate.

Pressure cannot be used, therefore, to make major changes in spray rate but it can be used to make minor changes. Keep in mind that you must maintain operating pressure within the recommended range for each nozzle type to obtain a uniform spray pattern and minimize drift.

The easiest and most effective way to make a large change in flow rate is to change the size of the nozzle tip. Depending on operating pressure, small changes in nozzle size can significantly change sprayer output. Nozzle manufacturers' catalogs can be used to select the proper tip size.

Travel speed is another important variable that affects the amount of pesticide applied. The application rate is inversely proportional to travel speed; that is, if you cut your travel speed in half, you will double the amount of mix applied per unit area. Travel speed, however, becomes less critical with most structural pesticide applications because the spray mixture normally is applied on a percentage basis and to the point of runoff. Still, a uniform walking speed must be maintained during such applications.

Precalibration Check. After making sure that your spray is clean and the correct nozzle for the intended application is installed, partially fill the tank with clean water. Operate the sprayer at a pressure within the recommended range and check the uniformity of the spray pattern. A worn or partially plugged nozzle will produce non-uniform patterns.

Liquid Application on a Percentage Basis. Structural insect control recommendations are commonly expressed as a percentage of active ingredient in the total spray mixture. The pesticide manufacturer usually provides a spray dilution chart on the label that lists the amount of formulated product that needs to be mixed with various quantities of diluent (usually water) to provide the desired spray mixture. Thus, insecticide mixtures can be prepared directly from label directions without the need for calculations.

Calibration of Hand-held (Single-nozzle) Sprayers

When applying pesticides on a percentage basis, you apply the spray mixture onto the site to the point of runoff. Thus, making a uniform application is much more important than knowing the actual output of the sprayer. However, if you ever apply pesticides on a unit area basis (e.g., per 1,000 square feet), then you will need to know how much area your sprayer will cover per tankful before you can determine how much pesticide product to put in the tank.

You can calibrate a hand-held sprayer by following these steps:

1. Measure a suitable test area similar to that which you will be spraying. A minimum test area of 10 feet by 25 feet (250 square feet) is suggested.
2. Fill the sprayer with water to a level that is easily recognized.
3. Spray the premeasured area using the same pressure and technique that you will use when applying the pesticide.
4. Refill the tank (with water) to the original water level. Be sure to note how much water you added to refill the tank.
5. Multiply the volume used for the test area by the appropriate number to get the volume of spray mixture you will need to spray 1,000 square feet. Change nozzles or adjust speed or pressure and recalibrate if necessary.
6. Determine the amount of pesticide needed for each gallon of water and the amount of spray mixture needed to cover the intended spray area.

Example: Your sprayer delivered 1½ gallons of water over 250 square feet. The insecticide label recommends that 12 ounces of liquid product be mixed in enough water to cover 1,000 square feet. Assume the spray capacity is 3 gallons.

1. What is the volume of application per 1,000 square feet based on the test area sprayed?

   Volume per 1,000 square feet = volume per 250 square feet x 4.
   = 1.5 gallons x 4
   = 6 gallons

2. How many ounces of insecticide are needed per gallon of water?

$$\text{Amount needed per gallon} = \frac{\text{amount needed per 1,000 square feet}}{\text{volume sprayed per 1,000 square feet}}$$
$$= 12 \text{ ounces} / 6 \text{ gallons}$$
$$= 2 \text{ ounces/gallon}$$

3. How many ounces of insecticide must be added to a full tank of water?

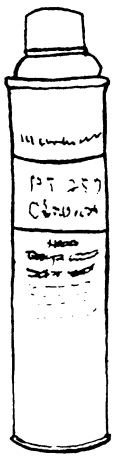
   Amount per tank = tank capacity x amount needed per gallon
   = 3 gallons x 2 ounces per gallon
   = 6 ounces per tank

4. How much area will one tank (3 gallons) of spray cover? Remember, the sprayer was calibrated for 6 gallons of water per 1,000 square feet.

$$\text{Square feet per tank} = \frac{1{,}000 \text{ square feet}}{\text{gallons needed per 1,000 square feet}} \text{ x gallons per tank}$$
$$= \frac{1{,}000 \text{ square feet}}{6 \text{ gallons}} \text{ x } 3$$
$$= 500 \text{ square feet per 3-gallon tank}$$

CANNED INSECTICIDES

Pressurized cans of insecticides became common in the late 1940s and were first used as aerosol foggers or "insect bombs." Canned insecticides in structural pest management include canned aerosol foggers (volumetric sprays, total release fogs), and pressurized liquid sprays. (The garden-type aerosol or the over-the-counter aerosol generally sold to the public for contact spraying is NOT included in either of these categories.)

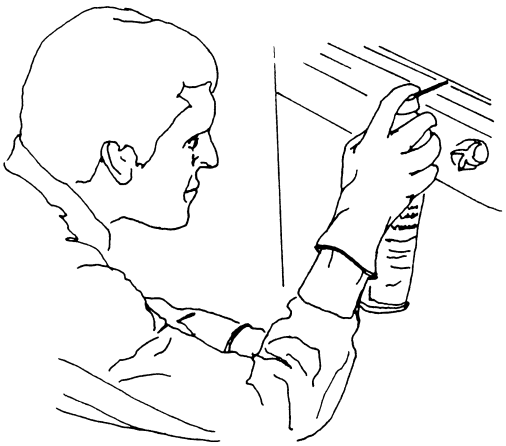


Canned Aerosol Pesticides

Canned aerosol pesticides consist of a pressurized fluid that produces an aerosol or fog droplet that floats in the air for a period of time, then settles to the ground. The droplet size is governed by the nozzle and valve at the top of the can. After use, a more or less uniform coverage will be attained on exposed horizontal surfaces. Very little pesticide lands on vertical surfaces, penetrates opened cabinets, or clings to undersurfaces. Droplets contact pests that have left hiding places; other insects that fly into the insecticide are also killed.

Canned-pressurized Liquid Sprays

Canned-pressurized liquid sprays are not aerosols. Because the coarse, wet spray is not made up of aerosol droplets, little becomes airborne. Com-pressed gas mixes with the pesticidal liquid in a pressurized spray. The gas forces the pesticide through the exit port, quickly vaporizes, and leaves pesticide on surfaces. When canned-pressurized liquids are part of a system that includes crack and crevice nozzles, the insecticide can be placed precisely on the target area. Using canned-pressurized liquid sprays requires a firm understanding of the target pests' habits so that pest habitat can be treated.



AEROSOL AND FOG GENERATORS

Power aerosol and fog generators break liquid pesticides into aerosol droplets. Reducing the liquid into droplets is done either mechanically (cold foggers) or by using heat (thermal foggers). Caution should always be taken to protect the applicator's respiratory system when these generators are used.

Cold Foggers

Cold foggers break an insecticide into aerosol-sized droplets and propel them into the air in a light cloud or fog. Large, ultra low dosage (ULD) and ultra low volume (ULV) cold foggers are mounted on trucks and used in mosquito control programs, to control pests in large warehouses, and for fly control in some operations. Cold fog generators drive pesticidal fog over a relatively large area. Droplets fall on flying or resting mosquitoes or are deposited in very small amounts on plant leaves on which mosquitoes rest.

Hand-held cold foggers are used inside buildings where they fill rooms, small warehouses, etc., with aerosol droplets. These floating droplets kill flying insects as well as exposed insects on horizontal surfaces. Fogs do not enter tight spaces or cracks and crevices. While some aerosol generators are used for crack and crevice applications, they also produce aerosol droplets that float in the air.

Thermal Foggers

Thermal foggers use heat to vaporize oil in an oil-based insecticide formulation. Large truck-mounted thermal aerosol generators are used in mosquito control programs—the insecticide fog rolls across open spaces, killing flying insects as air currents move it. Indoors, portable thermal foggers work like cold foggers except that droplets are smaller.

Precautions. When using fogging or aerosol-generating equipment indoors:

- Applicators should wear respirators.
- Occupants must leave until the area has been adequately ventilated.
- Pets must be removed; houseplants and aquariums must be covered, and aerating pumps turned off.
- Exposed foods and food preparation surfaces must be protected. After treatment, food preparation surfaces and any exposed utensils must be washed.
- Pilot lights and any other open flames must be extinguished. This is particularly critical when the oil-based thermal fog is used. Any spark can set off a thermal fog atmosphere.
- Thermal fog generators can burn surfaces that are contacted, including the operator.
- Aerosol droplets will not move into spaces where air is not circulating nor into any dead-air cracks and crevices (e.g., under molding into partially closed cabinets, drawers, closets).
- Furnace, air-conditioning, and ventilation equipment should be turned off. Ventilation will evacuate the insecticide and may carry it to other places outside the target area.
- After an appropriate interval, and before people or pets reoccupy an area, treated rooms should be thoroughly aired.

For General Application

Fogging should not be used as a single method of treatment but as a supplementary method to other types of application. Fogging or aerosol application is a general pesticide application and only pyrethrins or insecticides labeled for unclassified application can be used in this way. If fogging treatments need to be used increasingly more frequently, it means that the pest population is not being suppressed and may be increasing.

DUSTERS

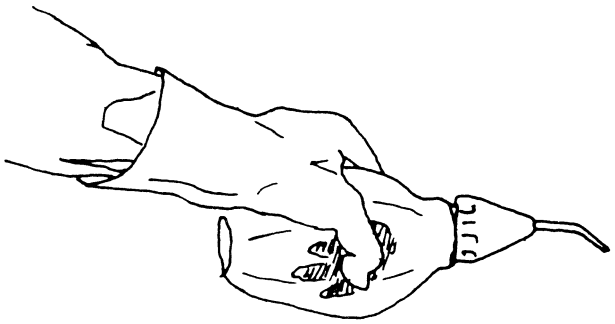
Dusters apply a fine, dry layer of a powdery mixture containing a small amount of pesticide. Dust applied on porous surfaces is not absorbed as liquids are—it rests on them like a layer of insecticidal powder. This dust accumulates on body parts (insect hairs, legs, and mouthparts) of insects that touch it. The insect absorbs pesticides in dusts in the same way as liquid sprays. Additionally, if the pest ingests particles (when grooming or cleaning itself), the dust can also cause stomach poisoning.

Hand Dusters

Pest management technicians commonly use three types of hand dusters: bulb, bellows, and plunger dusters. Dusts are also driven by gas in some formulations of canned insecticides, but with this method, dusts are applied the same as canned liquid pesticides.

Bellows dusters consist of a closed rubber cylinder made rigid by an internal spring, a spout at one end, and a stoppered refill hole at the other. These dusters, originally called Getz dusters, are held with the spout at the top. A slight pressure from top and bottom pushes air and dust from the spout. The more pressure applied, the more dust ejected. The spout is tapered at the tip, and slight puffs will propel small amounts of dust into cracks and crevices. The slight puffs distribute a thin layer of dust in the pest harborage.

Bulb dusters have a rubber bulb with a removable spout at one end. The spout screws off to allow for refilling. Dust application is similar to application with the bellows duster except that the bulb is squeezed. Both dusters come in several sizes.



Plunger dusters hold more dust than the first two hand-held dusters discussed. Plunger-type dusters have been used for garden dusting for a century, but the plunger duster used in structural pest management is smaller, made of high-impact plastic, and has several styles of nozzles.

Power Dusters

Most power dusters use compressed air to deliver insecticidal dusts to large spaces. Fire extinguishers have been converted to dusters and filled with compressed air. Other dusters are plastic and are pumped up similar to the hand-held compressed-air sprayer used to apply liquids. The plastic dusters release small or large amounts of dust with better control than the fire extinguisher type.

Dusts can be placed in wall voids, crawl spaces, and almost any unused space. Sometimes drilling into voids is necessary to inject dust. Great care must be taken to confine dust so that it does not drift and is not carried into non-target spaces. Remember to turn off pilot lights and flame- or spark-producing equipment if a combustible dust is used. Protect smoke alarms when using dust.

Dusters clog easily. They must be agitated often and the dust kept dry at all times. Dusters work much better if they are often washed and dried.

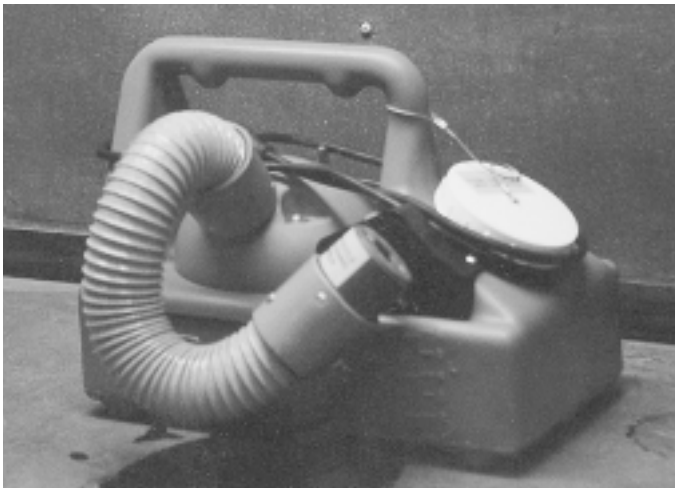


Figure 2-5. Power duster.

TRAPS

Traps, Bait Boxes, Monitoring Devices, and Pheromone Dispensers

Traps have been used for pest control for centuries. Rodent control traps range from snap traps to boxes that use trapdoors, spring-loaded multiple catch traps, and small animal traps. Rodent bait boxes, or bait stations, are containers that hold poisonous baits or glue boards. Under most conditions, they must be tamper-proof for safety. Other traps to catch pest birds are baited so the bird will enter and cannot get out. Fly traps are sticky tapes or cylinders that hang vertically, taking advantage of the fly's tendency to cling to vertical poles, strings, etc. Sticky traps are small glue boards used to catch cockroaches. These are used to monitor roach populations and to survey for other insects.

Pheromone traps lure insects with a pheromone (a natural attractant) to a sticky holding surface. These traps are used to evaluate insect populations. Their catches indicate which species are present. They may also be used to control or reduce pest populations.

Bait Stations

There are many kinds of bait stations. These devices confine toxic substances to units that are removable rather than leaving them exposed. In recent years, baits have become one of the most widely used formulations for cockroach and ant control. The bait stations offer natural insect habitat. They can augment sprays, dusts and fogs, or they can be used in place of other more toxic formulations. The key to using these devices is to know where and how to place them. Several products are now available that make baiting programs convenient, effective, and professional.

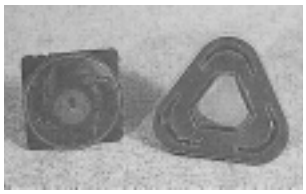


Figure 2-6. Bait stations for ants and cockroaches.

Bait Applicators

In addition to container baits and the powder bait formulations, two effective bait formulations are paste baits and gel baits. These formulations are packaged four ways:

1. Ready-to-use syringe-style cartridges—the applicator merely squeezes the syringe to apply the bait.
2. Containers of pastes—the professional, using a putty knife, applies the bait directly to the insect habitat.
3. Bulk paste baits—these can be loaded into a syringe that is then loaded into a bait applicator.

4. Prepackaged 30-gram and 100-gram bait tubes—these are easily loaded into the applicators.

Bait applicators (also referred to as bait guns) are available in several models. Dispensing tips on the guns allow the professional to apply baits into various types and sizes of cracks and crevices, which provides for effective pesticide placement into areas where the bait is most likely to be encountered by cockroaches.

SUMMARY

Using equipment safely and effectively in structural pest management requires special training and an understanding of the equipment being used. Equipment should be routinely inspected and maintained. Poorly cared-for equipment in bad repair is ineffective and dangerous.

To use pesticides efficiently and economically, without under application (lack of control) or over application (unsafe), applicators must understand the capabilities of their equipment and be able to depend on correct calibration. They must also be aware of the many types of equipment available. Sprayers, dusters, and foggers are just a few of the devices used in structural pest control. Other less toxic pest control devices such as traps and bait stations are being used more and more frequently. These may be used alone or in combination with other devices depending on the needs of the pest management program.

SECTION 1 CHAPTER 2

Review Questions

Chapter 2: Using Equipment in General Pest Management

Write the answers to the following questions and then check your answers with those in Appendix A in the back of this manual.

1-6. Match the following to the appropriate description:

A. Monitoring traps
B. Building plans
C. Inspection reports
D. Flashlight
E. Flushing Agent
F. Inspection Diagram

Which inspection tool would be the MOST appropriate for:

____ 1. Locating areas in the building that are warm and humid.

____ 2. Estimating the numbers of pests present before and after a control program (often uses pheromones).

____ 3. Listing the structural deficiencies contributing to the pest problem.

____ 4. Providing an overview of the structure and surrounding area.

____ 5. Viewing pests in their hiding places.

____ 6. Determining if pests are present in areas physically impossible to see.

7. Spraying is always considered essential to an effective structural pest management program.

A. True
B. False

8-12. Match the following to the appropriate description.

A. Backpack sprayer
B. Hand-held sprayer
C. Power sprayer

____ 8. Has a 2- to 5-gallon tank capacity and is pressurized by priming a piston pump.

____ 9. Uses a relatively large tank to spray building perimeters and lawns.

____ 10. Most likely sprayer to select for use indoors in smaller areas; pest control in cracks and crevices; applying flushing agents.

____ 11. Most likely sprayer to select for treating larger indoor areas (warehouses, commerical food facilities); outside, it is used on lawns, along fences, and around building perimeters.

____ 12. Produces two different flow patterns: pin-stream and flat-fan.

13. Which type of nozzle spray pattern delivers the largest amount of spray per minute at 20 psi?

A. Fine pin stream
B. Coarse fan, 50 degrees
C. Fine fan, 80 degrees
D. Broad pin stream

14. What is the advantage of using a crack and crevice extension tube on a nozzle?
    A. It allows crack and crevice application with little spilling or splashing.
    B. It is best for applying an even coat of spray on flat surfaces, including cracks.
    C. It delivers more than twice as much spray per minute to cracks and crevices.
    D. All of the above

15. High pressure must be maintained in hand-held sprayers to be effective.
    A. True
    B. False

16. New sprayers are well calibrated until they have been used one season.
    A. True
    B. False

17. A general effective pressure for fan spray applications is:
    A. Less than 10 psi.
    B. 10 to 20 psi.
    C. 20 to 25 psi.
    D. Greater than 25 psi.

18. For crack and crevice treatments, an effective pressure is:
    A. Less than 10 psi
    B. 10 to 20 psi
    C. 20 to 25 psi
    D. Greater than 25 psi

19. Which are proper procedures when filling a sprayer?
    A. Add the insecticide after completely filling the sprayer with water.
    B. Check to see that all components are working at the beginning of the day.
    C. Fill the tank to capacity.
    D. Use warm water to mix sprays.
    E. A & B

20. If a sprayer malfunctions:
    A. Repair it immediately.
    B. Increase pressure by pumping.
    C. Release pressure and do not use again until repaired.
    D. Use very soft, thin wire to clear nozzle after releasing pressure.

21. Equipment safety is best maintained by:
    A. Routine rinsing.
    B. Routine hose inspection.
    C. Scheduled cleaning.
    D. All of these.

22. What effect will increasing the pressure of a hand-held sprayer have on flow rate?
    A. Proportional increase in flow rate
    B. Decrease the flow rate
    C. Disproportional increase in flow rate
    D. Flow rate remains the same
    E. None of the above

23. What effect will increasing travel speed have on the pesticide application rate?
    A. Decrease application rate
    B. Increase application rate
    C. Application rate remains the same
    D. None of the above

24. What is the purpose of the precalibration check?
    A. Determine if equipment is operating properly
    B. Determine if insecticide is effective at controlling target pest
    C. Determine if spray application is uniform
    D. A & C
    E. A, B & C

25. Travel speed is less critical to structural pest management because the spray mixture is normally applied on a percentage basis and to the point of runoff.
    A. True
    B. False

26. In order to calibrate a hand-held sprayer, you must know:
    A. How much spray mixture your sprayer applies per unit area.
    B. How much area you can spray per tank.
    C. The rate of pesticide application as specified by the label.
    D. The amount of pesticide product to add to the tank.
    E. All of the above.

27. List the steps needed to calibrate a hand-held sprayer.

28. Your backpack sprayer tank holds 5 gallons. From calibrating your sprayer, you know that it applies 2 gallons of spray per 1,000 square feet. The labeling directions indicate a rate of 3 ounces of formulation per 1,000 square feet. How many ounces of formulation do you need per gallon of water? How many ounces per tankful?

29. How much area will one 5-gallon tank cover at a calibration rate of 2 gallons of spray per 1,000 square feet?

30. Fogging fills a room volume, including cracks, crevices and cabinets.

    A. True

    B. False

31-33. Match the following to the appropriate description:

    A. Canned-pressurized

    B. Fogging

    C. Dusting

_____ 31. Control mosquitoes over large areas.

_____ 32. A residual pesticide for places that are unused.

_____ 33. Crack and crevice nozzles allow treatment of insect habitat.

34. Bait stations have become one of the most widely used formulations for cockroach and ant control.

    A. True

    B. False

SECTION 1

CHAPTER 3

PEST MANAGEMENT AND CONTROL

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 the sequence of methods/activities involved in a pest management situation.
- Be able to relate the sequence of methods/activities involved in a pest management situation.
- Be able to recognize the components of integrated pest management.
- Understand the concept of pest thresholds.
- Understand the concept of resistance, how to recognize it, and possible ways to prevent it.

WHAT ARE PESTS?

Pests are not pests because of what they *are* (bedbug, yellow jacket) but because of what they *do* (suck blood, sting).

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 7B—Wood-destroying Pests). Unlike agricultural pests, they are less likely to cause direct economic damage to products. For instance, though roaches or rodents may cause an economic hardship when restaurants or food-packing plants are closed by legal action, the action is taken for reasons of human health. Likewise, carpet beetles in woolens or museum tapestries degrade clothing or works of art, but the reduction of value of the pieces is primarily for aesthetic reasons rather than consumption of woven wool.

Ecosystem

Defined by the way they behave in an environment or ***ecosystem,*** pests occur as a group or ***population*** of individuals of a particular kind (e.g., German cockroaches). Different populations that exist together are called 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 technician 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

Some pest management programs do not include more than the minimum follow-up, such as legally mandated record keeping. However, follow-up practices such as detailed record keeping, supervisor oversight, and a quality control program can make the difference between the success or failure of a pest management program.

APPROACHES TO PEST CONTROL

There are four approaches to current structural pest management activities: prevention, reaction, extermination, and integrated pest management. Pest management firms may utilize one, a few, or all of these methods depending on company resources and the types of pest management problems encountered.

Preventive Pest Control

In preventive 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.

Advantages

- Contracts can be fulfilled routinely.
- Work can be set up easily.
- The technician can proceed as rapidly as possible.
- Occupants are satisfied if pests do not appear.
- It is the most economical short-term approach.

Disadvantages

- Time alone governs the schedule.
- Inspections are brief.
- Boredom from repetition can affect the technician.
- Pesticides may be used regardless of whether there is an infestation.
- There is no evaluation.
- Records are brief.
- Long-term solutions are not provided.

Discussion

The least technical expertise is needed for preventive pest control, and the brevity of the activity and interaction gives clients the incorrect idea that controlling pests is elementary. This approach can be more efficient with a quality control program.

Reactive Pest Control

In reactive pest control, a technician responds to special, unscheduled calls and:

- Talks with clients.
- Makes an inspection.
- Identifies infested sites.
- 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 boredom is reduced.

Disadvantages

- Clients often mistakenly assume complete extermination.
- Clients are quick to anger if the problem recurs.
- Without a detailed inspection, failure is likely.
- Pesticides are often used as barriers if pests are not found.
- 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, usually a supervisor, responds to an appointment, and:

- Interacts with clients.
- Makes an ***intensive*** inspection.
- Recommends methods to reduce pest food, water, and harborage, such as sanitation, maintenance improvements, habitat alteration, etc.
- 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 supervisor gives the client a good understanding of the problem and the changes needed for control.
- The pest control supervisor 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

A high level of technical expertise is needed as well as superior ability to get client cooperation.

Integrated Pest Management

Commercial applicators are required, by Regulation 637 to receive training in integrated pest management (see Chapter 1). After a pest management technician makes a thorough inspection, an integrated pest management program is developed that includes a detailed plan and schedule. Elements of the detailed plan and schedule are:

- The designation of zones of probable infestation and sites of pest infestation within the zones.
- Recommendations for sanitation, maintenance improvements, habitat alteration, reduction of moisture, work procedure changes, safe practices, methods of application, etc.

Finally, pest management components are considered and integrated into the pest management plan (see below).

Advantages

- Long-term pest control procedures are used.
- Client management is involved.
- Costs are reduced over time.
- A reduction of pesticide use (e.g., elimination of preventive spraying) is attained.
- A low-toxicity pesticide response is possible.

Disadvantages

- Not every company or agency has the expertise to provide pest management programs.
- There is a labor-intensive start-up period.
- Costs are higher than "low bid."

Discussion

Integrated pest management was first used in protecting agricultural crops; in recent years, it has proven effective in structural pest management.

INTEGRATED PEST MANAGEMENT COMPONENTS

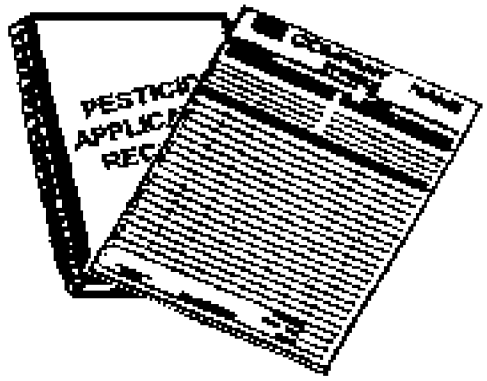
Pest management components are considered and integrated into an overall pest management plan.

Monitoring and Record Keeping

Inspection, continual sampling, and use of survey devices that result in accurate recorded pest counts are emphasized. Monitoring goes on in identified zones of potential infestation and is intensified in infested target sites. Non-target areas are not monitored.

Record books or logs are placed 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 pest management technicians and client supervisors.



Education, Training, and Communication

Communication is an on-going activity. Pests should be reduced to a level acceptable to the client. 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 group's designated liaison is important. Pest management supervisors, technical representatives, or consultants provide formal training.

Designated liaisons are clients with whom pest management technicians will review the record, problems, and control program each monitoring or treatment interval. Liaisons should explain the pest management program to other clients, i.e., staff members, tenants, workers, etc. Liaisons coordinate client efforts needed for the success of the program.

Integrated Control Methods

All practical measures to suppress the pest population to a tolerable level must be considered:

- 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 ***threshold*** is the level of pest density that can be tolerated. Integrated pest management is ***site-specific,*** for example, different numbers of cockroaches may be 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 in pest management are made without evaluation. Interviews, surveys, and record examinations should be made at scheduled times. Persons other than the pest management technician 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

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. 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 will always be carried by some members of the population.

How to Recognize Resistance

First, eliminate reasons that lead to failure to suppress a pest population. If questions such as these can be answered positively and the pest population still exists, the population might be a candidate for resistance testing:

- 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

Use of a multi-component approach such as integrated pest management prevents or delays resistance, which occurs when a single pesticide is consistently applied. When pesticides alone are used in a routine way for pest control, the pest population rebuilds between treatments. With repeated applications after population recovery, the more susceptible individuals are killed and those that are less susceptible become the parents of the next generation. Alternating pesticides with different modes of action (e.g., organophosphates and pyrethroids) can also help to reduce or delay resistance to pesticides.

SUMMARY

Pests are unwanted organisms—unwanted because their activities run counter to those of the people living in the same ecosystem. This ecosystem is made up of a number of animal populations, two of which are pests and humans. Together, these populations are called a community. The community and the biological (pest food, hosts, prey plants, etc.) and physical (hiding places, temperature, humidity) supporting factors are the components of an ecosystem—a basic, self-sustaining natural unit. Pest control takes place within this unit. To be effective, pest management acts on the parts of the ecosystem that will bring about the desired results.

Pest control approaches are set up to prevent, react to, eliminate, or manage pests. Each approach has advantages and disadvantages. The most complete (integrated) approach to pest management involves the coordination of many elements, depending on the nature of the infested site.

Pests are not evenly distributed in an ecosystem, so inspections are needed to locate them. To manage pests, the supporting factors of their population need to be identified and altered. When habitat alteration alone is not sufficient, pesticides can be used to reduce the pest population to a tolerable level.

Finally, an evaluation or follow-up assessment makes the control results last longer and provides information to the pest control technician and others concerned on how well the job was done.

SECTION 1 CHAPTER 3

Review Questions

Chapter 3: Pest Management and Control

Write the answers to the following questions and then check your answers with those in Appendix A in the back of this manual.

1. Define a pest in simple terms.

2. Define pest management.

3. Pest populations are part of an ecosystem. What elements make up an ecosystem?

4. In infested apartments, pest infestations are evenly distributed.

   A. True

   B. False

5. In a simple sequence of methods, which of the following is the first method or activity a pest control technician should do?

   A. Pesticide application

   B. Habitat alteration

   C. Inspection

   D. Follow-up

6-9. Match the following to the appropriate description:

A. Preventive pest control

B. Reactive pest control

C. Pest elimination or extermination

D. Integrated pest management

Select the pest management approach BEST described by the following:

_____ 6. A technician responds to special, unscheduled calls.

_____ 7. Detailed plan includes designation of infestation zones and several recommendations.

_____ 8. Approach most likely to use the maximum amount of pesticides.

_____ 9. Technician follows a pre-established schedule; pesticides are used regardless of whether or not there is an infestation.

10. The desired level of pest control is determined primarily by:

A. The client.

B. The technician.

C. The pest control supervisor.

D. The pest.

11. What is a pest threshold? What are the advantages of establishing threshold levels?

12. The integrated pest management approach to pest control, more than the other approaches, emphasizes:

A. Safe pesticide application.

B. The reduction of pests to a tolerable number.

C. Inspection.

D. Client communication.

13. Which of the following is not a component of integrative pest management?

A. Monitoring

B. Pesticide application

C. Preventive spraying

D. Record keeping

14. What is the drawback of consistently applying a single pesticide to control a pest population? What is the solution to this problem?

SECTION 1

CHAPTER 4

PEST MANAGEMENT IN FOOD-HANDLING AND OTHER SPECIALIZED FACILITIES

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 type of treatments can be applied to food and non-food areas.
- 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.

This chapter discusses some of the specialized facilities requiring customized pest management techniques including 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, that 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 and to follow pesticide label directions precisely. A properly designed pest management program must include the basic steps of **inspection, treatment** (or application of pest management procedures), **communication,** and **continual follow-up.**

PEST MANAGEMENT IN FOOD-HANDLING ESTABLISHMENTS

Commercial food establishments must comply with the high standards enforced by various government agencies, for example, sanitation standards 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. If the potential for contamination exists, the product may be deemed contaminated. Food processors are expected to follow the good management practices (GMPs) established to determine compliance with the FD&C Act. However, the FDA has established ***defect action levels*** for food products in recognition of the fact that it is impossible to attain zero levels of pest contamination even when GMPs are in place. These levels represent the maximum allowable levels for defects, such as the presence of insect fragments, mold, or rodent hairs. If tests show that defect action levels have been exceeded, enforcement action can be taken.

In addition to sanitation, the use of pesticides can help ensure that defect action levels are not reached. However, the GMP regulations do not allow any of the pesticides used in pest management operations to contaminate any food, surface, or packaging materials. For most pesticides, any level of residue in finished food constitutes an illegal residue. Therefore, most pesticides must be used in ways (such as crack and crevice application) that ensure no residues in food or packaging materials.

Food plants involved in meat, poultry, egg, and egg products processing and operations must operate under even more detailed and stringent U.S. Department of Agriculture regulations, which require frequent inspections. As extensive as these regulations are, a great deal is still left up to the discretion of the USDA inspector in charge. This regulatory process works as follows:

- Many pesticides cleared by the EPA for use in food-handling establishments either are not permitted for use in USDA-inspected food plants or are permitted but can be applied only under specific conditions and preparations. This is a case where the pesticide label does not reflect the only applicable law.
- To determine what pesticides can be considered for USDA-inspected plants, the pest management professional must consult the "USDA's List of Proprietary Substances and Non-Food Compounds Authorized for Use under USDA Inspection and Grading Programs."
- In some cases, a USDA inspector in charge may not permit the use of a pesticide in a plant even though it may be on the list of proprietary substances. As an example, an inspector may allow the use of certain types of pesticides only when the plant is in non-production status.
- Where pest problems are serious, the USDA may temporarily waive its restrictions on the use of certain pesticides and permit their use, but only under USDA direction.

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 they are detected by regulatory inspectors or before complaints are received from customers. Some areas to inspect for real or potential pest problems in food-handling establishments follow.

Exterior areas:

- Pest harborages 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

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? Do personnel observe door-closing policies?)

Storage:

- Proper practices (Is stored material kept 16 to 18 inches away from walls?)
- 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

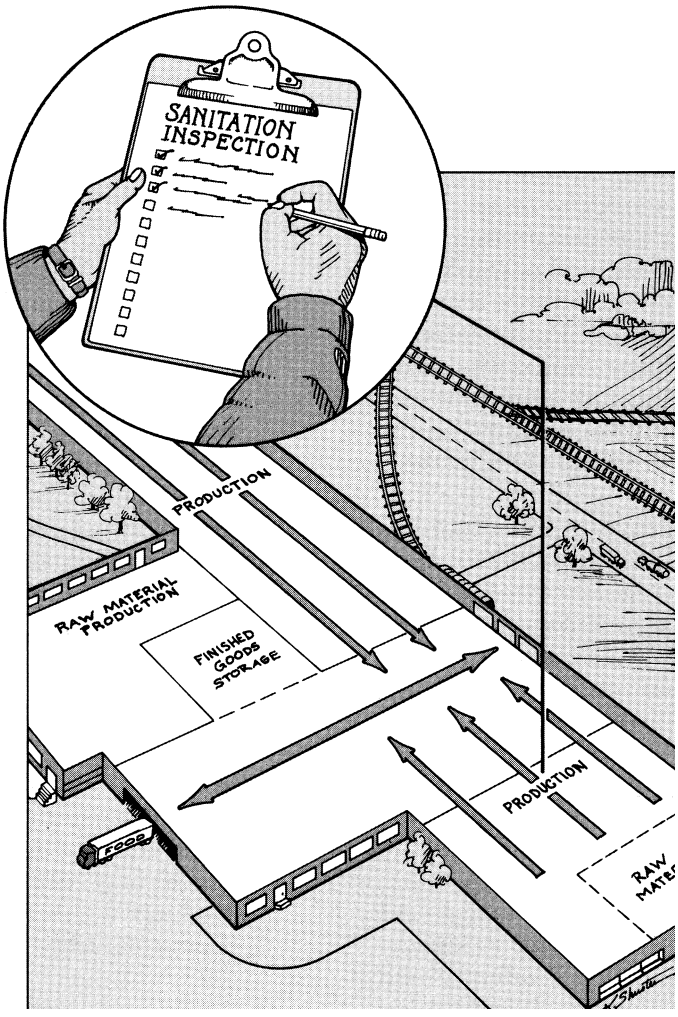


Figure 4-1. The sanitation professional must inspect all areas of a food plant.

Insecticides in Food-handling Establishments

Insecticides applied in food-handling establishments must not come in contact with or possibly contaminate food products. For this reason, it is important to distinguish between food and non-food areas of these establishments. **Non-food areas** may include locker rooms, lavatories, machine rooms, boiler rooms, rubbish rooms and garages. These are areas where food is not normally present, except perhaps as it is being transported from one area to another. **Food areas** include any location where food is stored or processed. Certain restrictions apply to the types of insecticides and treatments that can be used in food or non-food areas. Some definitions and general guidelines follow. For more specific details on whether a product can be used in food or non-food areas, refer to the product label.

Residual insecticides are those products applied to obtain insecticidal effect lasting several hours or longer. There are four types of residual applications: **general, barrier, spot, and crack and crevice.** Each may be used in certain areas of food-handling establishments as directed by the product label.

General treatment is application to broad expanses of indoor surfaces such as walls, floors, and ceilings, or outside treatments. This is permitted only in non-food areas using only those insecticides so registered.

Barrier treatment is usually considered the application of pesticides to thresholds and other entrances, the foundation, and the soil adjacent to the foundation. A barrier treatment with residual sprays, dusts, or granules may be beneficial in controlling outdoor pests that may become invaders or nuisances when populations build up.

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

Crack and crevice treatment is the application of small amounts of insecticides into cracks and crevices in which insects hide or through which they may enter a building. Such openings commonly occur at expansion joints, between different elements of construction, and between equipment and floors. The openings may lead to voids, such as hollow walls, equipment legs and bases, conduits, motor housings, or junction or switch boxes. The crack and crevice treatment may entail the use of sprays, dusts, or baits. It can be used in food areas as long as the insecticide is placed into cracks and crevices.

Residual insecticides may be applied when food establishments are in operation unless the label of the product being used specifically indicates that all operations must be stopped at the time of application.

When using ***nonresidual insecticides*** (defined as those applied to obtain insecticidal effects only during the time of treatment) as space treatments (aerosol, ULF and fog treatments), the application should be made while the food-handling establishment is not in operation and

exposed foods are removed or covered. Also, food-handling surfaces should be cleaned before use. However, the use of nonresidual insecticides as ***contact treatments*** (which means hitting the target pest with a wet spray for immediate insecticidal effect) can be done while the establishment is in operation. Both space treatments and contact treatments are considered general insecticide applications.

Rodenticides in Food-handling Establishments

Rodenticides are usually applied in attractive food baits or as liquids. Such baits ordinarily require "tamper-resistant" containers that are designed to protect animals and children as well as to avoid contamination of food (see Chapter 16). When placing bait stations, special attention is required to protect the containers from damage and from being stolen or tampered with. Rodenticides may be used outside the facility to intercept rodents before they gain entry. They may be used inside the facility as long as they do not come in contact with food.

Pest Management for Supermarkets

A supermarket is an example of a food-handling establishment in which the flow of food and other materials is enormous. Such stores can be thought of as centers of intense activity: food and supplies funnel in from many sources, and this merchandise disperses widely into the community. In addition, supermarkets are often closely inspected by state and local public health officials and other regulatory agencies (e.g., FDA and USDA). Any presence of pest infestation can be detrimental to the store's reputation and business. Due to frequent pest introductions 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.

Key Pests:

- Cockroaches
- Mice and rats
- Flies (especially fruit flies [*Drosophila* spp.] around produce)
- Stored-product insects
- Birds (outdoors)

Pest 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

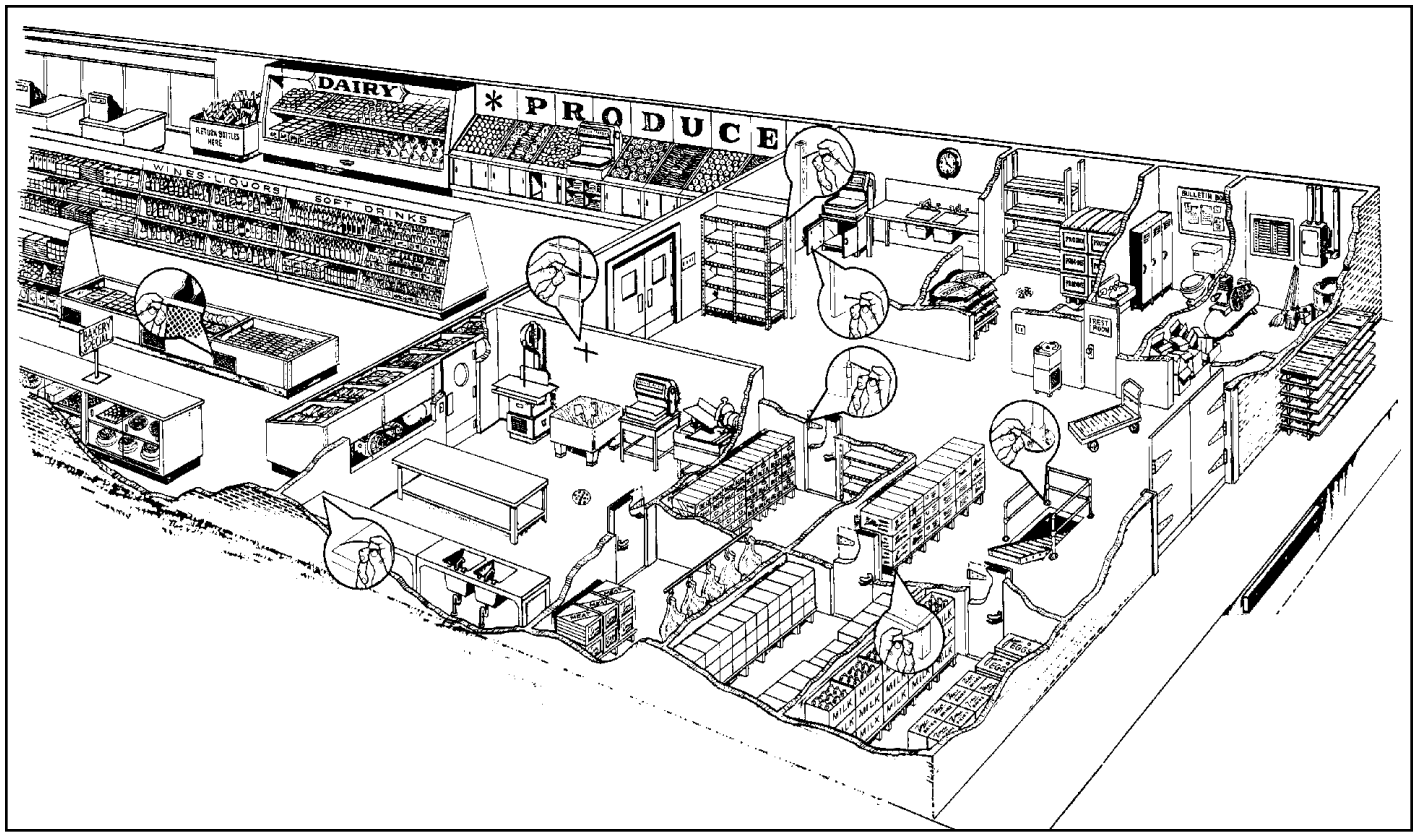


Figure 4-2. Large, modern supermarkets are complex structures through which enormous amounts of food and many store customers flow each day (Whitemore/Micro-Gen).

- 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 Applications:

- 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.).
- Prefer the use of baits, crack and crevice treatments, and dusting of voids rather than general treatment.

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 throughout the facility.
- Check that spilled food and other clutter has not collected under or 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 (see Laws and Regulations section in this chapter).

PEST MANAGEMENT IN OTHER SPECIALIZED FACILITIES

According to the State of Michigan Regulation 637, Category 7A applicators must receive training in integrated pest management (IPM) before they can make certain types of pesticide applications in schools, health care facilities, and public buildings (see Chapter 1). IPM is considered the preferred method of pest control in these sensitive areas. IPM provides safe, effective pest control and discourages the over application or unnecessary use of pesticides. Always check state and federal laws before applying pesticides in any specialized facilities or public buildings.

Pest Management in Schools and Day-care Centers

Pest control in schools and day-care centers must protect both the health and safety of the children and staff and minimize pest damage to structures and personal property. In addition, the quality of the educational environment will be improved by avoiding annoyances and disruption of work and learning caused by insects, rodents, and other pests. The success of an IPM program in schools depends on communication and cooperation between the pest control technician, administrators, staff, and students. In addition, according to Regulation 637, parents must be notified in writing before (or after, in the case of emergencies) any pesticides are applied in schools or day-care centers (see Chapter 1). When the respective roles of all people involved in the pest management system are identified and agreed upon, and when these people communicate with one another, effective and less expensive protection of the site and the people can be achieved with reduced risk. The pest control technician's role in a 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
- Head lice
- Flies

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 checklists.
- 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 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 room for treatment.

- 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?

During Pesticide Applications:

- Insecticide applications can not be made in schoolrooms/day-care centers unless the rooms will be unoccupied for at least four hours or longer if specified by the product label (see Regulation 637, Chapter 1). 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 time period for reentry (see Regulation 637, Chapter 1).
- Stress use of tamper-resistant bait formulations wherever appropriate. Baits and crack and crevice formulations are considered safer 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

Health care facilities include 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 thousands. 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 coming in contact with skin wounds) or indirectly (i.e., through contamination of hospital food or medical supplies). According to Regulation 637, a detailed IPM plan is also required for pest management in health care facilities (see Chapter 1). Key points for management of pests in health care facilities follow.

Key Pests:

- German and brown-banded cockroaches
- Ants (especially pharaoh ants)
- Mice
- Flies (especially associated with drains and decaying materials)

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 Inspections:

- 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, nor until all vapors and odors are gone. Coordinate with the nursing staff to have patients moved.
- 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

Pest management in zoos and pet stores represents 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
- 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 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.

SUMMARY

An effective pest management program always begins with a thorough inspection of the facility to identify sanitation problems and to locate pest harborages. The pest control technician must be aware of the unique needs of the facility and must set up a treatment program that is consistent with these needs. Facility staff must be informed of the treatments being applied and advised on all matters of safety and avoiding contamination. Continual monitoring, record keeping, and follow-up are required to ensure that the pests are being controlled and that the staff are satisfied with the results. Whenever possible and practical, less-toxic means of controlling pests, such as sanitation, baiting, crack and crevice, and spot treatments should be used instead of general spraying.

SECTION 1 CHAPTER 4

Review Questions

Chapter 4: Pest Management in Food-handling and Other Specialized Facilities

Write the answers to the following questions and then check your answers with those in Appendix A in the back of this manual.

1. The most important pest control technique in a food-handling establishment is:
   A. Insecticide use.
   B. Rodenticide use.
   C. Baiting.
   D. Sanitation.
   E. A & B

2. Which federal law regulates allowable levels of extraneous matter in food products?
   A. Food, Drug and Cosmetic Act of 1938
   B. FIFRA
   C. Regulation 637
   D. OSHA

3. For most pesticides, any level of residue in finished food products constitutes an illegal residue.
   A. True
   B. False

4. Pesticides used in meat, poultry, egg, and egg product processing plants:
   A. May be used if cleared by the EPA and the FDA.
   B. May be used if specified by the product label.
   C. May be used regardless of label directions if cleared by USDA inspectors.
   D. May be used if specified by the product label and permitted for use by USDA inspectors.

5. Crack and crevice treatment includes sprays, dusts, or baits.
   A. True
   B. False

6. Contact treatment must never be applied while the food-handling establishment is in operation.
   A. True
   B. False

7. Which of the following pesticide treatments in a food-handling facility would most likely ensure no amount of residue in food, on preparation surfaces, or on packaging materials?
   A. Space
   B. Crack and crevice
   C. General spraying
   D. A & C

8. What are defect action levels?

9. If a pesticide is on the USDA's List of Proprietary Substances, you can be certain it is available for use in USDA-inspected food processing plants.

   A. True

   B. False

10. It is possible to obtain a waiver of restrictions from USDA-inspected plants when pest problems are serious.

   A. True

   B. False

11. Where could an insecticide be applied as a general treatment (i.e., broad application)?

   A. Refrigeration rooms

   B. Locker rooms

   C. Kitchen areas

   D. None of the above

   E. All of the above

12-17. Match the following to the appropriate description:

   A. General

   B. Barrier

   C. Crack and crevice

   D. Spot

   E. Space

   F. Contact

   _____ 12. Application can not be made while establishment is in operation.

   _____ 13. Permitted only in non-food areas; broad application.

   _____ 14. Used to prevent outdoor pests from entering.

   _____ 15. Can be used in food areas if placed properly into areas where insects hide.

   _____ 16. Treatment should not exceed 2 square feet.

   _____ 17. Hit target pest for immediate effect.

18. Nonresidual insecticides:

   A. Have long-term effects.

   B. Include crack and crevice treatments.

   C. Effects last only during time of treatment.

   D. Include both space and contact treatments.

   E. C & D

19-26. Match the following to the appropriate description:

   A. Health care facilities

   B. Supermarkets

   C. Zoos/pet stores

   D. Computer facilities

   E. Schools/day-care centers

Which special circumstances are *MOST* applicable to which type of facility?

   _____ 19. Risk of damage to sensitive equipment from insect infestations and pesticide applications is the primary concern.

   _____ 20. Risk of secondary pesticide poisoning from eating treated pests.

   _____ 21. Risk of human bacterial infections a primary concern.

   _____ 22. Head lice are a particular problem.

   _____ 23. Stored-product pests are a particular problem.

   _____ 24. Increased risk of pest introductions due to flow of goods.

   _____ 25. Prohibiting food presence highly recommended.

   _____ 26. Parents must be notified before any pesticides are applied.

27. Before a commercial applicator can apply pesticides in a schoolroom, he/she must:

   A. Be certain the rooms will be unoccupied for at least 4 hours or longer if specified by the product label.

   B. Inform school administrators and staff of decision to use pesticides.

   C. Consult the USDA's List of Proprietary Substances.

   D. Select only non-residual pesticides.

   E. A & B

28. When applying insecticides in a hospital:

   A. Using nonresidual insecticides is preferred.

   B. Low-odor crack and crevice or spot treatments are preferred.

   C. Inform patients before pesticide application.

   D. B & C

   E. A & C

29. The purpose of monitoring a building with traps and bait stations is to:

    A. Set defect action levels.
    B. Set action thresholds.
    C. Eliminate pests from a structure.
    D. Determine if pests are present and/or the current level of pest infestation.
    E. B & D

30. According to Regulation 637, commercial applicators must receive training in IPM before applying pesticides in:

    A. Schools.
    B. Day-care centers.
    C. Nursing homes.
    D. Hospitals.
    E. All of the above.

31. Baiting is considered safer to use than general insecticide applications in:

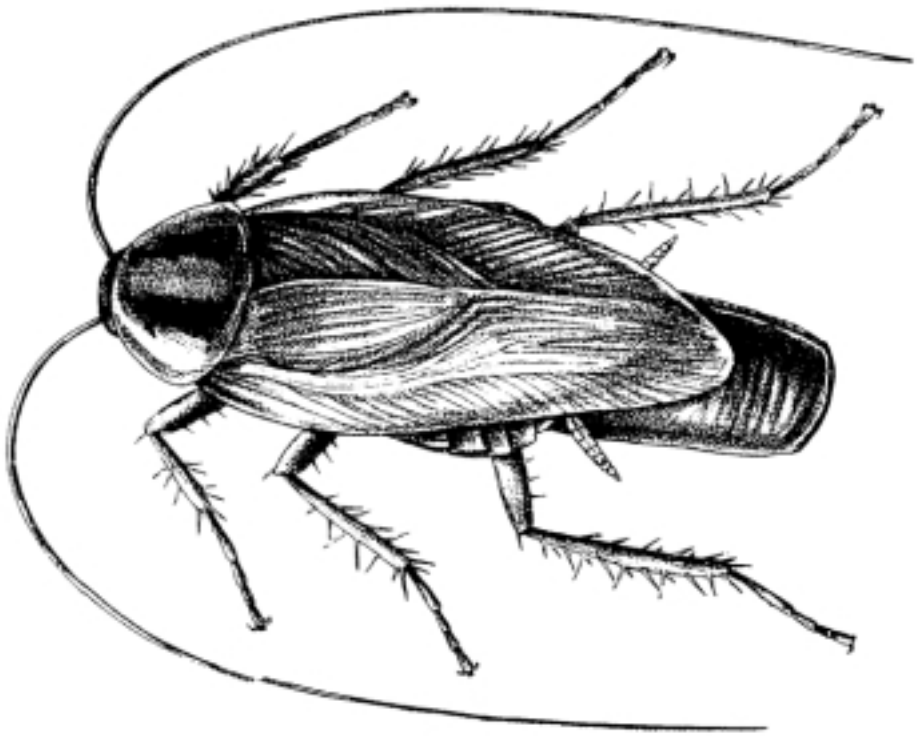
    A. Computer facilities.
    B. Health care facilities.
    C. Food-handling facilities.
    D. Zoos/pet stores.
    E. All of the above.

SECTION 2

STRUCTURE-INFESTING PESTS

The pests discussed in this section consist principally of those that infest structures and for the main part remain inside, generation after generation, as long as the necessities of food, moisture, and harborage hold out. Many of those species are cosmopolitan—they have been carried over much of the world by human migrations of trade or conquest. A few (some of the cockroaches, for example) have adapted so well to human habits that their origin cannot be identified with assurance. Ants are the possible exception to this grouping. They could be considered either structural (Section 2) or invading pests (Section 3). Some ant species can persist indoors 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 suitable indoor habitat. Therefore, habitat alteration is a primary means of controlling these pests



SECTION 2

CHAPTER 5

INSECTS AND THEIR RELATIVES

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.

Plants, in many forms from great trees to tiny mosses, cover the land. The plant kingdom began as microscopic single cells—pond scum. Their descendants are the algae, bacteria, and fungi living today. Larger prehistoric plants developed from their smaller ancestors; finally, flowering plants, modern shrubs, and trees evolved.

Forebears of insects were the first animals to move onto land—before plants had flowers. As plants developed, so did the insects, feeding on evolving plant structures such as flowers, pollen, nectar, leaves, bark, stems, roots, and their dead remains.

At the time of early insect development, the land had a uniform climate: one with moisture and temperature adequate for constant growth. Later, the surface land mass (continents) shifted, moving northward and southward, creating seasons, and setting the stage for the world as we know it.

INSECTS AS PART OF THE ANIMAL KINGDOM

Living things are divided into the plant kingdom, 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 the "arthropods" include spiders, mites, ticks, millipedes, centipedes, crabs, shrimp, and insects.

Phylum Arthropoda

An arthropod has:

- A body made of segments, which 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 with two prominent structures that end in needle-like piercing tips. They have four pairs of legs and two body regions: the mouthparts and legs are attached to the first region; the reproductive organs and digestive system are contained in the second.

Crustacea. This class includes aquatic crabs, lobsters, and shrimp, as well as crustacea that dwell on land (pillbugs and sowbugs).

Myriapoda. This group is made of two classes—millipedes and centipedes. The millipedes are many-segmented and worm-like; they are cylindrical with short antennae and two pairs of legs per segment. Centipedes are also many-segmented and worm-like, but they appear more flattened and have one pair of legs per segment; antennae and hind legs are long (all legs of the house centipede are very long).

Insecta. This class contains the insects: arthropods with three body regions—head, thorax, and abdomen. The head bears a single pair of antennae. The thorax bears three pairs of legs and usually wings. The abdomen contains most of the digestive system and the reproductive organs.

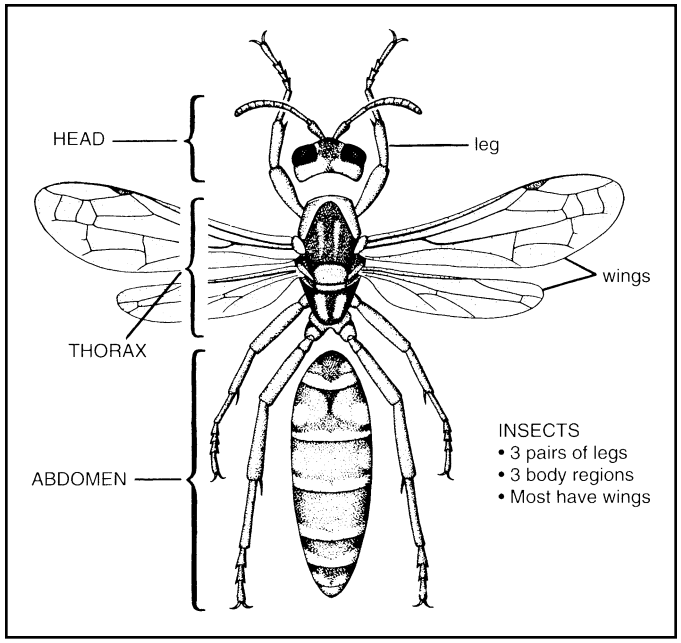


Figure 5-1. The three principal regions and parts of an insect's body, as shown on the paper wasp. (Provonsha)

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., the order of moths and butterflies, or the order of beetles).

Orders are subdivided into **families** made up of related **species.** Species of animals can be thought of as specific kinds of animals. Very closely related species are grouped together in a **genus.** Species or types of animals (and plants) 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 is the species name (always lower case). Both are written in italics or underlined (e.g., *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 at pliable or soft places. It does not grow continuously. Arthropods grow in stages. They form a new, soft exoskeleton under the old one, then shed or ***molt*** the old one. The new skeleton is larger and allows the animal to grow. The new exoskeleton is white at first, but it hardens and darkens in a few hours. After the molting process, which usually takes place in hiding, the arthropod resumes its normal activities.

Development

Most arthropods hatch as tiny individuals and grow by molting, usually keeping the same appearance until they become adults. However, a spectacular and very 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 by the technical term ***metamorphosis,*** which means "change in form." Three main types of metamorphosis have been identified.

Group 1. Simple Metamorphosis

This group, including the order of silverfish, makes no drastic change in form from juvenile to adult. They simply hatch and grow larger by molting periodically. Only a few orders are included in this group.

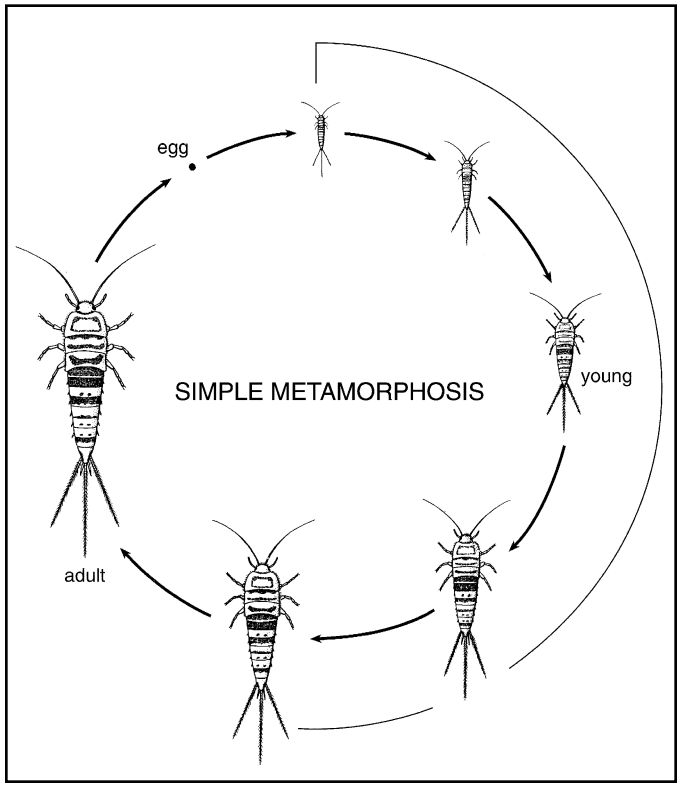


Figure 5-2. Development with simple metamorphosis (example: silverfish). (Provonsha)

Group 2. Gradual Metamorphosis

In this group (e.g., cockroaches, crickets, grasshoppers, box elder bugs, earwigs, etc.),

individuals hatch from the egg only partially resembling the adults. The immatures, or ***nymphs,*** do not have wings. Winged insects are always adults. Fourteen orders develop in 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.

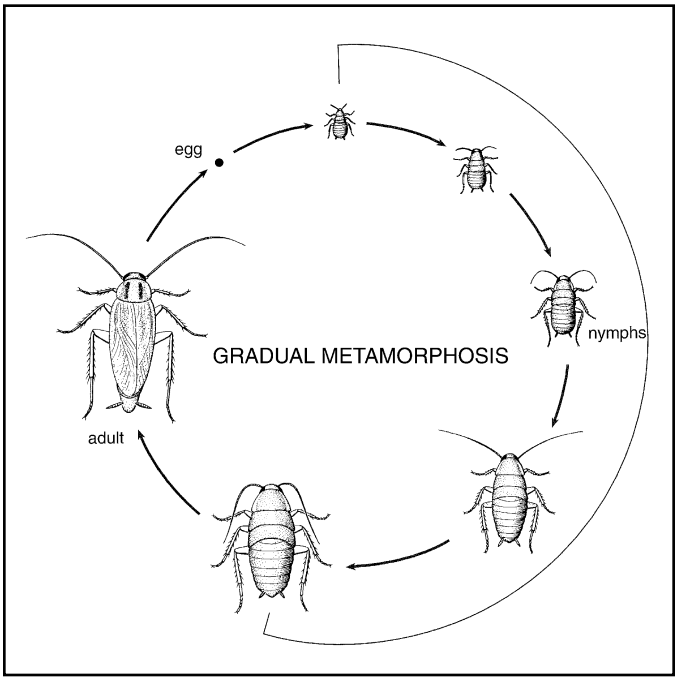


Figure 5-3. Development with gradual metamorphosis (example: cockroach). (Provonsha)

Group 3. Complete Metamorphosis

Insects that develop by complete metamorphosis make a complete change in appearance from juvenile to adult. These nine orders contain the majority of insect species. ***In fact, they number more than all of the other species in the entire animal kingdom!*** This major group includes beetles, moths and butterflies, flies, fleas, and stinging insects (ants, bees, and wasps).

Insects with complete metamorphosis hatch from eggs as ***larvae*** (grubs, maggots and caterpillars). The mission of the larval stage is to feed and grow. Larvae continue their development through a number of molts until they become mature; then, they change into ***pupae.*** The purpose of the inactive pupal stage is one of change or body rearrangement resulting in a complete change into the adult stage. Reproduction occurs during the ***adult*** stage.

Considerations of Pest Management

These developmental stages of insects with complete metamorphosis support rather than compete with each other. It is as if two or three completely different animals with different needs and habits represent the single species. The larvae feed and live in one habitat and sometimes leave that area to pupate a short distance away. The adult emerges and often eats a different food and lives in another area, returning to the larval feeding site only to lay eggs. For this reason, pest controllers manage species with complete metamorphosis in different ways according to the different stages, where each lives, and what each does. The reader will want to pay special attention to sections that discuss the growth cycle, behavior, and harborage (the area in which the animal lives and finds its food) of each animal.

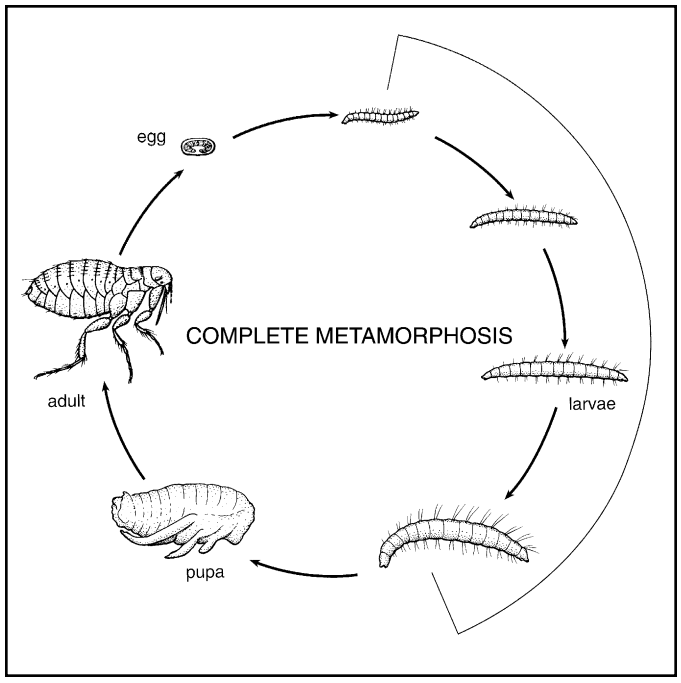


Figure 5-4. Development with complete metamorphosis (example: flea). (Provonsha)

SUMMARY

The class Insecta belongs to the phylum Arthropoda, which includes other non-insect classes (spiders, mites, centipedes, crabs, etc). Arthropods are grouped in the same phylum because of similar features, including segmented bodies and exoskeletons. Insects are distinguished from other arthropods in that they do not keep the same appearance as they grow. Instead, they undergo a metamorphosis or a change in body shape as they develop from one stage to another. It is important that the pest control technician understand the different stages of insect development so that the appropriate pest control technique can be applied.

SECTION 2 CHAPTER 5

Review Questions

Chapter 5: Insects and Their Relatives

Write the answers to the following questions and then check your answers with those in Appendix A in the back of this manual.

1. Which of the following characteristics do all arthropods share?
   A. Six legs
   B. Appendages in pairs
   C. Undergo complete metamorphosis
   D. Nymphs are wingless
   E. A & B

2-5. Match the following with the appropriate description.

A. Arachnida
B. Myriopoda
C. Crustacea
D. Insecta

_____ 2. Class that includes pillbugs and sowbugs.
_____ 3. Two body regions; class includes scorpions.
_____ 4. Many-segmented bodies.
_____ 5. Three body regions.

6. On which segment of an insect's body are the legs and often the wings attached?
   A. Thorax
   B. Head
   C. Abdomen
   D. Antennae

7. Which is the correct ranking of divisions used in classification?
   A. Class, order, family, species, genus
   B. Order, class, family, genus, species
   C. Family, class, order, species, genus
   D. Class, order, family, genus, species

8-13. Match the following with the appropriate description.

A. Cockroaches
B. Ants
C. Silverfish
D. All three

_____ 8. Undergo simple metamorphosis.
_____ 9. Nymphs are wingless; adults have wings.
_____ 10. Hatch from eggs as larvae.
_____ 11. Grow by molting.
_____ 12. Have an exoskeleton.
_____ 13. Undergo complete metamorphosis.

14. Why is it important for pest control technicians to understand the different stages of insects that undergo complete metamorphosis?

SECTION 2

CHAPTER 6

COCKROACHES

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 have survived for more than 300 million years. Ancient cockroach fossils have the same appearance as today's cockroaches: oval and flat with long legs and antennae. The modern cockroach has the same need for a warm, moist climate. Worldwide there are 3,500 kinds of cockroaches. Though most live wild in the tropics, a few, called urban cockroaches, prefer the even temperature and moist conditions that humans maintain in their homes and workplaces.

Applying pesticides where and when the insects can be found allows technicians to manage infestations most effectively. Knowing similarities among and differences between species is important. Communicating this knowledge will give clients more confidence in the professional ability of their pest controllers. By considering the habits discussed below, the applicator can consider effective measures to control cockroaches. Except for size, all cockroaches are relatively similar in overall shape and appearance. They are nocturnal and stay in the dark whenever possible. When they are seen in the open or in the light, it usually means that a large infestation is present. Cockroaches also like tight places where their bodies can touch surfaces both above and below. As they grow to adulthood, they will seek varied harborage (living space) to accommodate their increasing size. Cockroaches are particular about where they live—they do not uniformly infest one room or all rooms.

The four most common kinds of cockroaches found in Michigan are the **German, brown-banded, American,** and **Oriental.** Four other kinds, or species of cockroaches that are mainly a problem on exotic plants are the **Australian, brown, smoky brown,** and **Surinam.** Two other species of cockroaches that may be a pest problem in Michigan live primarily outdoors. They are the **woods** and **Asian** cockroaches.

COMMON COCKROACHES

Geman Cockroach *(Blattella germanica)*

The German cockroach not only is the cause of the largest number of phone calls requesting pest control but also represents the largest number of control failures among household pests. It is very successful at infesting human structures and withstanding pest control activity. Pest control technicians will need to double their efforts in analyzing every German cockroach infestation and should be prepared to use more than one technique to bring the infestation under control.

Appearance

Adult German cockroaches are ½ inch long or slightly longer. Males are brown to dark brown with two black stripes on the ***pronotum*** (the area just behind the insect's head) and have a tapering abdomen. Females are usually darker and their abdomens are more rounded.

Nymphs are sometimes not recognized as cockroaches—they appear quite different from the adults. After molting, they will be ivory white for several hours before turning dark. People who see them at this time often think they are albino cockroaches. Actually, such observations mean that the cockroach population is so large that nymphs cannot find unoccupied spaces in which to hide and molt, for they normally molt in private. In the first stage, nymphs are very dark. In later stages, a pale tan stripe appears down the middle from front to rear. This stripe divides the nymphal markings into two dark, long stripes. The stripes remain as two dark streaks on the adult's pronotum, while the rest of the body is covered by tan or brown wings.

Figure 6.1. German cockroach, *Blattella germanica*.

Life Cycle

Eggs. The egg capsule of the German cockroach is about ¼ inch long. Half of it protrudes from the female's abdomen. It is carried in this way for three weeks until it is dropped, about one day before the eggs hatch. The drop usually takes place in a secluded portion of the infested habitat. If the egg case is dropped much more than one day before hatching time, the young die. Each egg capsule contains 30 to 40 eggs. Altogether, the female will produce from four to eight capsules in her lifetime. The first few capsules will have a full complement of eggs, but subsequent capsules can contain fewer.

When the female goes into safe hiding, she takes the capsule with her, reducing exposure to possible harm. In extreme danger, she will detach the capsule and flee. The capsule has a relatively impervious surface to protect its eggs. It does, nonetheless, receive moisture from or give moisture to the female. In extremely dry atmospheres, the female will abort the egg capsule. In all large infestations, egg capsules are present. Even if the cockroach population is eliminated, as many as one in every twenty egg cases can still hatch. It takes two months for adult German cockroaches to develop after hatching from the egg.

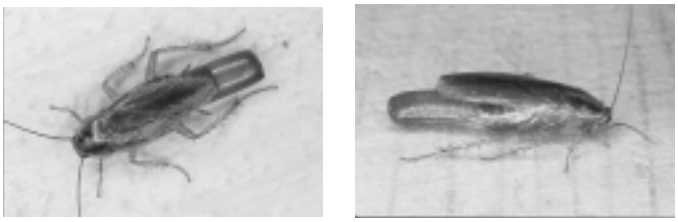


Figure 6.2. Female German cockroach with egg case.

Nymphs. The eggs hatch when the nymphs inside create pressure that splits the case and allows the young to escape. They often will stay around the opened egg capsule after hatching. Then, as they develop, they ***molt*** six or seven times before reaching the adult stage. Females often have one more molt than males. When molting, nymphs are very soft and vulnerable. Nymphs can be differentiated from adults because they do not have fully formed wings.

Adults. Winged adult cockroaches emerge from the last nymphal molt. They join a nearby aggregation made up of other adults and larger nymphs. The aggregation is held together by a very short-range odor called the ***aggregation pheromone.***

Behavior and Harborage

Aggregations of cockroaches live in areas of high humidity and nearby food. They prefer harborage into which they can fit closely. As the number of roaches increases and favorable harborage is filled, roaches are forced to leave the aggregation or remain in less favorable harborage. They will find these new sites during their foraging periods just before dawn and after dark.

Aggregations:

- Serve as the natural group where large nymphs (soon to be adults) and adults of both sexes remain together, thus facilitating mating.
- 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 adult. Proximity for mating is especially important, as males and females have to touch antennae and exchange sex pheromones to initiate mating. After mating, females feed intensively for several days, then seek secure hiding places where they can be safe with their egg capsules.

Such seclusion means that females with egg capsules feed less frequently and are exposed to pesticides less often. Preventive pesticide applications are likely to be less toxic by the time female roaches come in contact with them. Clients often report seeing no adult roaches after a technician's last treatment but later will observe "little black ones." The client is reporting seeing small nymphs that hatched from egg capsules that were deep in harborage. These capsules are from females that did not come in contact with superficially or poorly applied pesticides.

Foraging. The foraging pattern of German cockroaches is much less random than one would expect. The

roaches leave their harborage and usually go to the first perpendicular surface they find, where they stop, turn, and move along the intersection of the two surfaces (usually a floor and a wall). As 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 harborage, 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 harborage and areas for population expansion into adjacent rooms or apartments.

German cockroaches are not likely to leave favorable harborage unless population pressure or other negative changes occur. Such "other" changes can be caused by:

- Intensive cleaning.
- Pesticide applications.
- Reduction of temperature or humidity.

If cockroaches find new locations with favorable conditions, they can migrate from one harborage 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 infestations are found only outside the structures from which steady roach migrations occur, and near dumpsters and garbage cans (sources of food).

Control and Management of the German Cockroach

Inspection

With Flashlights. An active flashlight inspection is the most intensive method of locating roaches. The technician can search dark, undisturbed, or remote places of roach harborage that a client may have thought too inaccessible. Hand mirrors, magnifying hand lens, or other small tools may be helpful to some technicians.

With Traps. Passive use of sticky traps is a common inspection or monitoring method used for roach detection. Correct trap placement depends upon the applicator's understanding of roach foraging habits. For instance, jars and traps baited with fermenting materials such as beer, bread, potatoes, or softened raisins indicate population size but are not especially helpful for finding harborage.

Habitat Alteration

Once German cockroaches have been identified infesting a structure, the first choice for control is habitat alteration. Technicians should explain that changes can be made that will alter or eradicate the insect problem. These recommendations should include how clients can eliminate or restrict material that supports roach populations. Some recommendations are to:

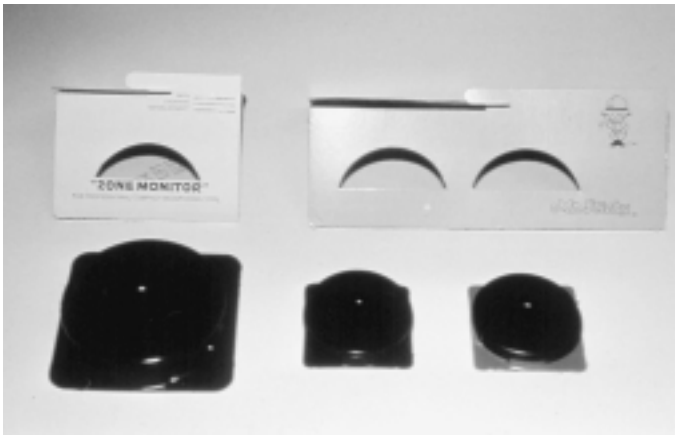


Figure. 6.3. Sticky traps and containerized bait.

- Keep food in tightly sealed, roach-resistant containers (paper and cardboard are not roach-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: drains, vents, ovens, and stoves.
- Store food waste and other organic materials in plastic containers with tight-fitting, snap-on lids.
- Thoroughly rinse out bottles and cans with soapy water before storing for recycling.
- Screen vents, windows, and ducts to reduce roach passageways. Caulk around the edges of screens to make a tight barrier.
- Dehumidify and provide ventilation to dry out moist areas. German roaches survive longer in higher relative humidities.
- Reduce available drinking water. Sources of drinking water are sink traps, drain pipes, wash basins, tubs, toilet bowls, condensation on pipes and windows, leaky pipes and faucets, pet dishes, etc.
- Vacuum up roaches and egg cases. The crevice attachment can be used to vacuum roaches out of cracks. Dispose of the vacuum bag in a sealed plastic bag.
- Caulk and/or paint to seal cracks and eliminate hiding places for roaches.

Pesticide Application

If pesticide treatments are required, concentrate on injecting pesticides into active harborage rather than preventively treating uncertain harborage.

- The ***crack and crevice*** type of pesticide application is preferred. Use a narrow diameter extension tube in infested cracks and crevices to provide a thorough application of residual insecticide (under furniture, drawers, and sinks, around pipes, and in high cabinets). First remove utensils and supplies in cabinets; do not treat shelf surfaces.
- In homes, offices and other non-food areas, use ***spot applications*** and apply 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 ultra-low-dosage dispensers. They flush cockroaches out, causing them to cross residual pesticide applications, or they kill the insects by direct contact. They lack crack and crevice penetration. 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.
- ***Bait stations*** should not be contaminated by sprays or dusts that may be repellant. Place an adequate number of stations in or very near harborage.

Follow-up

A technician should record the data collected with each activity. Such information is helpful in understanding the problem over time and in providing clear communication with clients.

Brown-banded Cockroach *(Supella longipalpa)*

Brown-banded cockroaches are generally not as widespread as the German cockroach, but where they find favorable harborage, such as warm apartments and overheated office buildings, they build up infestations rivaling those of the German cockroach. They can be found across the United States.

Appearance

Adult brown-banded cockroaches are the size of German cockroaches—about $^1/_2$ inch long. The female is a little longer than the male. Her wings are reddish brown to dark brown, and a little shorter than her broad, rounded abdomen. The male, slightly less than $^1/_2$ inch long, has wings that are dark brown at the base but light brown at the tips, which are slightly longer than the tapering abdomen. Both sexes have a light band behind the pronotum at the base of the wings, and another full or partial band about one-third of the way back from the pronotum. The pronotum is dark brown with very light side margins and never shows two stripes as the German cockroach does. Nymphs are dark with two very light bands separated by a dark band just behind the pronotum. These nymphal markings are more obvious than the banded markings of the adults.

Figure 6.4. Brown-banded cockroach, *Supella longipalpa*.

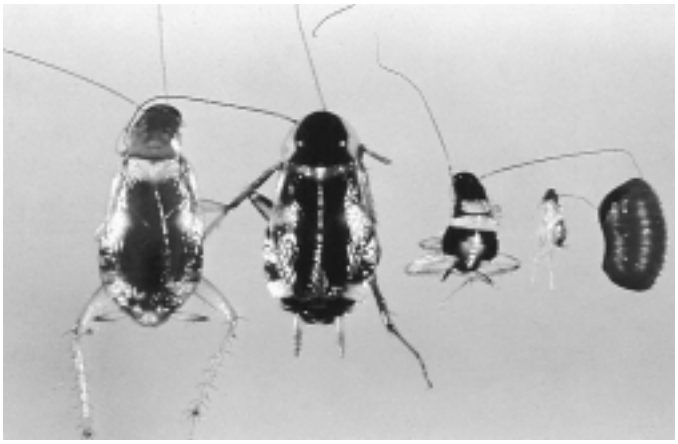


Figure 6.5. Brown-banded cockroach male and female, nymphs, and egg capsule.

Life Cycle

Eggs. The brown-banded cockroach female forms an egg capsule, carries it less than two days, then glues it to an object in the harborage site. The capsule is very small, only about $^1/_8$ inch long, and a little less than $^1/_8$ inch wide. It is oval and a light tan to brown. The female usually glues these in clumps underneath furniture, behind

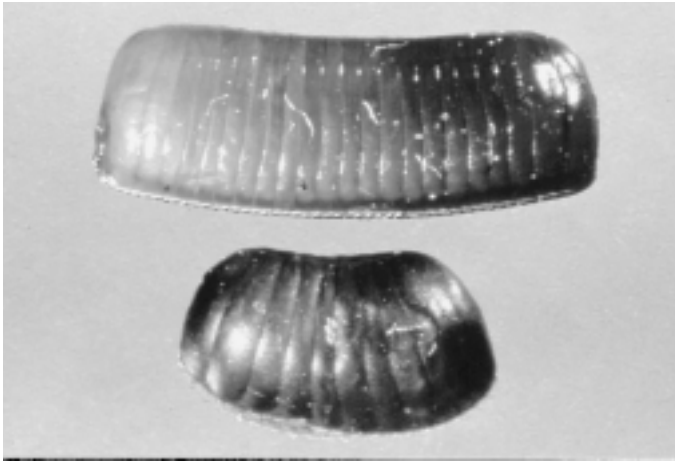


Figure 6.6. Egg cases of German (top) and brown-banded (below) cockroaches.

kitchen cabinet drawers, and in corners inside cabinets and cabinet frames. These capsules hatch in about 50 days; they take longer at cooler temperatures (e.g., up to 95 days at a room temperature of 72 degrees F). A female may deposit 14 egg cases in her lifetime; 13 to 18 nymphs can hatch from one egg case.

Nymphs. Nymphs molt six to eight times in five to six months at normal room temperatures. At higher temperatures, the nymphal period is nearly halved.

Figure 6.7. Brown-banded cockroach nymphs.

Adults. Adult brown-banded cockroaches live about six months past the nymphal stage. Males fly readily, as can be seen when lights are turned on during their foraging periods. The females do not fly.

Behavior and Harborage

Brown-banded cockroaches, like German cockroaches, build up 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, such as those in refrigerators, electric clocks, light timers, televisions, and radios.

Control and Management of the Brown-banded Cockroach

Inspection

Search areas frequented by the brown-banded cockroach. Look for roaches and egg cases.

Habitat Alteration

Apply caulk around pipes and other wall penetrations. Where possible, suggest that the client clean and replace shelf paper and drawer liners, 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 to lay her eggs. The tiny wasp larvae eat the roach eggs, then emerge from the capsules, fly to windows where the sexes meet and mate—and the cycle begins again. This wasp parasite has been used as part of a cockroach management program.

Pesticide Application

- Use a narrow-diameter extension tube in infested cracks and crevices to provide a thorough application of residual insecticide: under furniture, drawers, and sinks, and around pipes and high cabinets. First remove utensils and supplies in cabinets; do not treat shelf surfaces.
- Consider pesticide formulations not readily absorbed by unpainted wood.
- Bait stations with a long active period are effective but should not be contaminated by sprays or dusts that may be repellant. Place an adequate number in or very near harborage.
- Spot sprays often break down before egg capsules hatch.
- Space sprays lack crack and crevice penetration.

No pesticide application used alone will control roaches satisfactorily without habitat alteration

AMERICAN COCKROACH *(Periplaneta americana)*

The American cockroach is cosmopolitan and is often cited in historical accounts. Its worldwide distribution has been aided by its ability to thrive aboard ships. Like the Oriental cockroach, the American cockroach is sometimes called "waterbug." In the southern United States, it is called "palmetto bug."

Appearance

Adult American cockroaches are long: 1 $^{1}/_{3}$ to 1 $^{1}/_{2}$ inches. The wings of the male extend slightly beyond the tip of the abdomen, but those of the female do not. This roach is reddish brown and its pronotum is ringed by an irregular light color that is almost yellow. Often this margin is bright and wide, darkening toward the center of the pronotum. In other cases, the lighter margin is barely discernible, but it is always present on the rear margin of the pronotum.

Figure 6.8. American cockroach, *Periplaneta americana.*

Life Cycle

Eggs. The American cockroach female drops her egg capsules about one day after they form. The capsules are only about $^{5}/_{16}$ inch long and $^{3}/_{16}$ inch wide and are sometimes covered with dust because they are left by the female in out-of-the-way places. Egg capsules that are clean, dark, and dropped in the open are an indication of a high population. Where climate allows American cockroaches to spend most of their lives outdoors, egg capsules can be found in moist wood. Although females produce egg capsules throughout the year, they produce more of them in the summer. An egg capsule can form in about one week, so from 12 to 24 capsules can be produced in the warm months. An average of 14 eggs per capsule hatch in 30 to 50-plus days.

Nymphs. When they first hatch, nymphs are gray. After their first molt, they are reddish brown like the adults. They molt up to 13 times before reaching adulthood. Depending on temperature nymphs can take from 6 to 20 months to mature. American and Oriental nymphs can be difficult to tell apart.

Adults. Adults commonly live more than one year, giving the American cockroach an entire life span of 20 to 21 months. Flying American cockroaches are found only in the southern United States.

Behavior and Harborage

Large populations of American cockroaches live in warm moist habitats. They winter in decaying trees and woodpiles. They can be found in boiler rooms or other harborage with water heaters, floor drains, water sumps, and warm, moist basements.

Control and Management of the American Cockroach

Inspection

Search areas that provide warmth and high humidity.

Habitat Alteration

- Caulk around plumbing and other penetrations in walls; 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.

Pesticide Application

- 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 areas of known infestation.
- Use space sprays to quickly reduce large populations indoors.
- Large bait stations are effective when properly placed in proper quantities.
- A sex pheromone is available to attract males to traps.

Follow-up

On-going monitoring is important because of the long life span of this roach.

Oriental Cockroach *(Blatta orientalis)*

The Oriental cockroach is often called the waterbug and sometimes the black beetle, or just (incorrectly) beetle. It is the most common urban roach in England.

Appearance

Adult Oriental cockroaches are very dark brown or shiny black. The female is slightly longer than the male—1 $^{1}/_{4}$ inch compared with 1 inch. Unlike other domestic cockroaches, the female does not develop wings, but produces only short, triangular wing pads. The male has wings, but they are short and broad, leaving about one-quarter of the abdomen exposed.

Figure 6.9. Oriental cockroach, *Blatta orientalis.*

Life Cycle

Eggs. The Oriental cockroach female produces an average of eight egg capsules from spring to midsummer. Unlike other indoor cockroaches, the Oriental roach produces only one generation per year where temperatures are cool in winter. The egg capsule is carried for little more than 24 hours, and then is placed in a protected spot; it is irregularly shaped, black, $^{3}/_{8}$ inch long, and $^{1}/_{4}$ inch wide. Eggs hatch in two months.

Nymphs. Nymphs are active from about March through much of the summer. During this period they molt seven to ten times and are reddish brown to black except in the first stage, when they are pale tan. The older brown Oriental cockroach nymphs are very difficult to distinguish from American cockroach nymphs.

Adults. In early spring, only adult Oriental cockroaches are found. By late spring, nymphs are abundant. As nymphal numbers increase, the adults die off, and by

August, any adults are new ones. By fall, almost the entire population is adult. Neither males nor females fly.

Behavior and Harborage

Oriental cockroaches favor crawl spaces, spaces between the soil and building foundations, the undersides of stoops and sidewalks, landscaping mulches, water meters, basements and their floor drains, and other such moist places. These cockroaches frequently live in floor drains that drain directly outside; these drains are also used as entrances to homes. The Oriental cockroach prefers starchy food and builds up populations around garbage cans. They tolerate lower temperature ranges than other roaches and may winter in rock walls or such protected sites. These cockroaches are more sensitive to lack of water than other roaches.

Control and Management of the Oriental Cockroach

Inspection

Search areas of high humidity.

Habitat Alteration

- Caulk all penetrations through ground-level walls.
- Stop water leaks, screen equipment overflow drains, and take overflow water away from buildings; 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.

Pesticide Application

Many of the same insecticide applications used to reduce American cockroaches will work for the Oriental cockroach. Particular attention must be paid to pesticide degradation due to moisture.

Follow-up

Numbers observed in the spring may appear low or under control, only to build up by midsummer.

PLANT-ASSOCIATED COCKROACHES

Australian Cockroach *(Periplaneta australasiae)*

Another relative of the American cockroach, the Australian cockroach was introduced from outside the continental United States.

Appearance

The Australian cockroach looks similar to the American cockroach but is slightly shorter and somewhat oval. Australian cockroach adults have conspicuous light-yellow margins on the pronotum. The reddish brown base color is slightly darker, and the outside edges of the wings just behind the pronotum are light yellow, sometimes nearly white. Nymphs are brown but have yellow streaking across each thoracic (middle section) and abdominal segment.

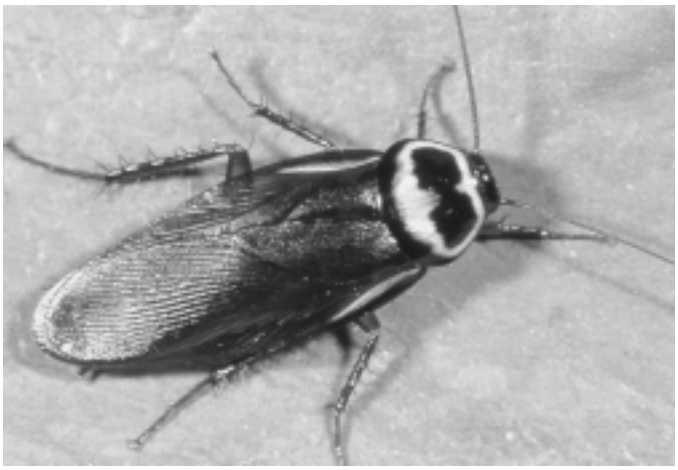


Figure 6.10. Australian cockroach, *Periplaneta australasiae.*

Behavior and Harborage

The Australian cockroach is more commonly introduced with trees and other plants used inside shopping malls than the brown cockroach. It burrows into soil and is not easily detected. The Australian cockroach can build up in large numbers in buildings with high humidity.

Control and Management of the Australian Cockroach

Inspection

Inspect the entire infested area. Concentrate on locating the plant soil in which they are burrowing.

Pesticide Application

- The American roach sex pheromone can be used to trap or bait males.
- Large bait stations and granules can be placed in and around plants; limit water where possible to protect baits; maintain a high degree of sanitation to force the roaches to baits.
- Plants may have to be removed and treated elsewhere.

Follow-up

Continue monitoring until the population is eradicated.

Brown Cockroach *(Periplaneta brunnea)*

The brown cockroach, another close relative of the American cockroach, is transported in plant soil.

Appearance

The brown cockroach closely resembles the American cockroach in color but lacks the light coloration on the margin of the pronotum. Its ***cerci*** (short appendages at

the end of the abdomen) are wider and have blunt tips. The American roach has slender, pointed cerci. It is not as uniformly dark as the smoky brown cockroach.

Figure 6.11. Brown cockroach, *Periplaneta brunnea.*

Life Cycle

Eggs. Egg capsules of the brown cockroach are over ½ inch long and contain an average of 24 eggs. They average 35 days from deposition to hatching.

Nymphs. Nymphs mature in a little over nine months. The antennal segments of the first nymphal stage are white at both the base and the tip.

Adults. Adults are associated with trees and feed on plant materials. This species has a somewhat yearly growth cycle.

Behavior and Harborage

The brown cockroach is commonly found from eastern Texas to Florida. They build up large populations in some areas. They live outdoors but enter homes on occasion, and they often are transported into new areas such as the northern United States with the movement of plant soil. Brown cockroaches can be found in places such as sewers, crawl spaces, and garages.

Control and Management of the Brown Cockroach

Inspection

Pay careful attention to outdoor populations near buildings. Inspect shrubs and trees that have been imported for indoor use.

Habitat Alteration

See American cockroach.

Pesticide Application

- Treat areas where specimens are found rather than typical American cockroach harborage.
- Large bait stations can be placed in and around plants, and sprays or dusts can be used for residual control.

Follow-up

Continue monitoring until the population is eradicated where these roaches occur inside.

Smoky Brown Cockroach *(Periplaneta fuliginosa)*

The smoky brown cockroach is a relative of the American cockroach and resembles it in size and shape. These cockroaches are more common in the southern United States.

Appearance

Adult smoky brown cockroaches are slightly over 1 inch long, and both sexes have wings that are longer than the abdomen. Their very dark brown mahogany color is striking; no light markings appear on the pronotum or wings. Nymphs, like adults, are also dark brown. Antennal tips of young nymphs are white, and the base segments of the older nymphs' antennae are white.

Figure 6.12. Smoky brown cockroach, *Periplaneta fuliginosa.*

Figure 6.13. Smoky brown, Australian, and Oriental cockroaches.

Life Cycle

Eggs. The egg capsule of the smoky brown cockroach is large and dark brown. The female usually glues it to objects in the harborage. An average of 17 eggs are in each capsule; as many as 24 eggs have been found. Nymphs hatch within 50 days.

Nymphs. Nymphs that hatch in summer overwinter.

Adults. The life cycle of a smoky brown cockroach is about one year. A large adult die-off occurs each fall. Both sexes fly.

Behavior and Harborage

The smoky brown roach is found in the Gulf States from central Texas to Florida, in Georgia, South and North Carolina, southern California, and in some parts of the Midwest. It is a plant feeder and occurs in greenhouses. Though it is mainly an outdoor roach, it is often transported indoors. Populations build up outside homes and enter around doors, garages, and in the eaves of roofs where they live in gutters and under roof shingles and easily find their way into attics. This cockroach is very dependent on moisture. In areas of high humidity, populations can build up and infest every level of a structure.

Control and Management of the Smoky Brown Cockroach

Inspection

Search gutters, roof overhangs, and attics.

Habitat Alteration

- Tighten doors and window wells.
- Eliminate overhanging tree limbs (especially pines).
- Keep gutters clean.
- Close all roach entry at the roof from the edges of eaves to house walls. Use care not to obstruct screened ventilation areas.
- Attach lights away from the house.

Pesticide Application

- Use microencapsulated insecticides at the edge of the roof, behind gutters, etc.
- Use dusts in infested areas of attics where the dust will not get into living spaces.
- Use granules in outdoor harborage.

Follow-up

Monitor, especially in unoccupied vacation homes. Attics of all infested homes can be heavily infested, especially unoccupied homes.

Surinam Cockroach *(Pycnoscelus surinamensis)*

The Surinam cockroach is another hitchhiker in plant soil and infests plants used in building interiors.

Appearance

The adult female is about one inch long, and has a shiny black head and pronotum, with uniformly dark brown or sometimes lighter brown wings. No males are found in the United States.

Figure 6.14. Surinam cockroach, ***Pycnoscelus surinamensis.***

Behavior and Harborage

The species is primarily established in southern Florida and Texas.

Control and Management of the Surinam Cockroach

Granules or soil drenches labeled for that use can be administered to the plant soil. Large bait stations and sticky traps will control roaches that leave the pot. Plants may need to be removed and treated elsewhere.

OUTDOOR COCKROACHES

Woods Cockroach *(Parcoblatta* spp.*)*

There are several species of woods cockroach. They all live outdoors exclusively.

Appearance

The adult female is slightly less than 1 inch long and her short wings cover less than half of her abdomen. She cannot fly. The male woods cockroach is 1 inch long and has richly colored, dark brown wings that extend well over the tip of its abdomen. The woods cockroach is slender (three times longer than it is wide). The pronotum and the fore-part of the wings of both sexes are margined with light yellow or white, but the pronotum is very dark between these margins.

Behavior and Harborage

Woods cockroaches live in rotted logs, tree stumps, hollow trees, stopped-up rain gutters, under loose tree bark and in piles of firewood. The males fly to lights, landing on windows and door screens. They then make their way indoors or fly into the house. Sometimes they are brought in with firewood. Once indoors, however, woods cockroaches soon die. Human habitats do not provide the moisture of their normally shaded woodland. Even with sufficient moisture, they would not live long without females. Woods cockroaches range across the southern, midwestern, and eastern United States into Canada.

Control and Management of the Woods Cockroach

Male woods roaches can be excluded by caulking and tightening around screens in rooms that face woods habitat. Outside lights that attract flying roaches can be regulated. Windows and doors where light-attracted roaches may enter should be tightly screened. No pesticide applications are needed.

ASIAN COCKROACH *(Blattella asahinai)*

Appearance

The Asian cockroach looks nearly identical to the German cockroach.

Behavior and Harborage

The Asian cockroach is essentially an outdoors roach; its populations are seasonal. It is native to and widespread in Southeast Asia and other parts of the Pacific, but it has successfully colonized urban neighborhoods after being introduced into the Tampa, Florida area. It is usually brought into Michigan by travelers from southern states. This roach lives outside and builds up under fallen leaves and ground cover. It favors shady, moist areas and builds up rapidly under trees. Unlike most roaches, it is attracted to light, and adults fly to lighted windows, doors, yard lights, and parking lot lights at dusk. From these points they often crawl into buildings or fly to indoor room lights. The Asian cockroach begins building up its population in spring and produces several generations through the summer. It is primarily limited to warm and moist regions.

Control and Management of the Asian Cockroach

Inspection

Inspect large yard trees and waste areas next to suburban yards. Locate favorable harborage. Inspect motor homes that have traveled to southern states.

Pesticide Application

- Select pesticidal baits most favored by this species for use in their harborage.
- Before migration to lights begins, apply pesticides labeled for use on cockroaches to populations in favored harborage outdoors.

Follow-up

Monitor to find when populations begin to increase.

USING BAITS TO CONTROL COCKROACHES

For many of the species listed above, baits may be an effective, less toxic alternative to pesticide sprays. Simply defined, a bait consists of an active ingredient that is mixed with food that acts as an attractant. Cockroaches are killed by ingesting lethal doses of the toxicant. Some tips for successfully using baits follow.

- Always inspect thoroughly before using baits. Baiting requires more thorough inspection than spraying. Cockroach control will not be achieved if harborages are not identified.
- A spatula or large syringe may be preferred over a bait gun to control large populations of cockroaches (follow the label directions).
- Use a bait gun to insert bait into small cracks where a syringe or spatula will not work.
- Bait along the edges and intersections where cockroaches migrate to and from their harborage to feeding areas.
- Bait in corners (cockroaches tend to congregate there).
- Keep areas dry to enhance gel baits (fix leaking pipes, dripping faucets, etc.). Cockroaches seeking moisture will be drawn to the gel baits.
- Try to bait or use sticky traps at cockroach entry points. New cockroaches can be brought in on paper bags, boxes, and clothes. If any new activity is noted, target that area.
- Seal cracks to reduce harborage. Caulking used to seal cracks can be an effective method of reducing cockroach populations.
- Don't fill cracks with bait. Filling the entire crack takes away harborage and reduces bait acceptance. Leave small gaps between bait inserted into cracks.
- Look for changes in the environment and bait accordingly. Bringing in new plants, bottled-water stations, coffeemakers, fish tanks, refrigerators, and smoke detectors creates new cockroach harborages. Inspect and bait as required.
- Baiting requires intense monitoring. Cockroaches may turn up in new areas after populations are scattered with various controls.
- Insect growth regulators (IGR) overcome feeding suppression. Improving the cockroach appetite enhances the effectiveness of the baiting program.

SUMMARY

Four factors explain the success of the German cockroach as a pest in human habitations. They:

- Flourish in moist/humid environments.
- Can utilize human clutter and interior building design for their harborage.
- Feed on a wide range of food and are not subject to periodic scarcities.
- Develop in a short period of time allowing them to adapt and overcome environmental stresses and pesticide applications.

German cockroaches in particular live on the same wide range of foods that humans eat and have no strict preferences that would result in periodic scarcities that might endanger their numbers. Accepting a variety of foods shortens not only foraging time, but foraging distance as well. German cockroaches build large populations quickly. They produce a large number of eggs per capsule and have a shorter developmental period than other domestic cockroaches. Urban cockroaches are adaptable. Generally, their rapid population growth allows for increased variation in each generation. This means that some individuals can chemically break apart a pesticide in their bodies rendering it ineffective. When these roaches mate, some pass this resistance on to some of their offspring, resulting in a population with increasingly larger numbers resistant to the pesticide.

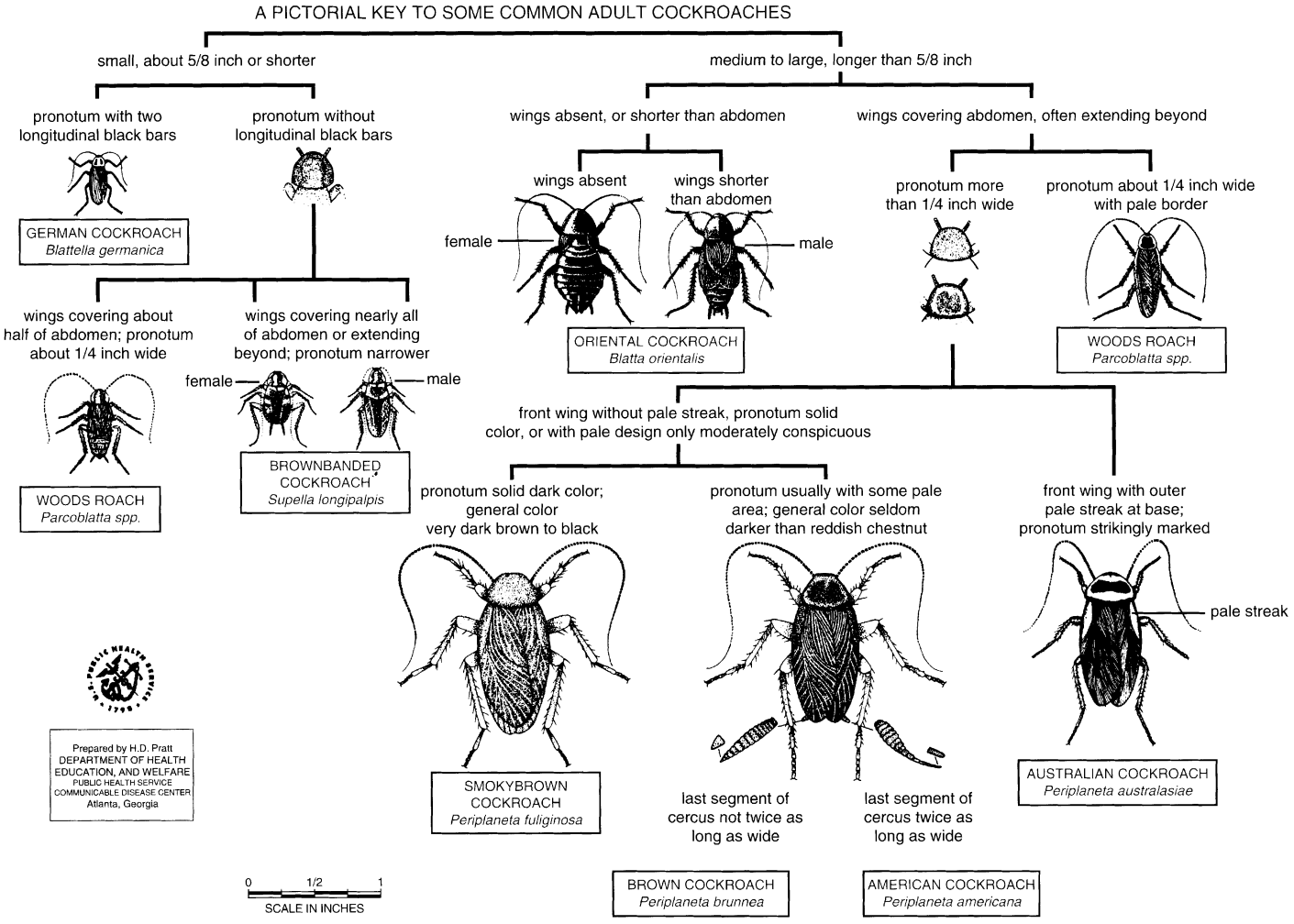


Figure. 6.15. A pictorial key (from the CDC) of eight cockroach pest species.

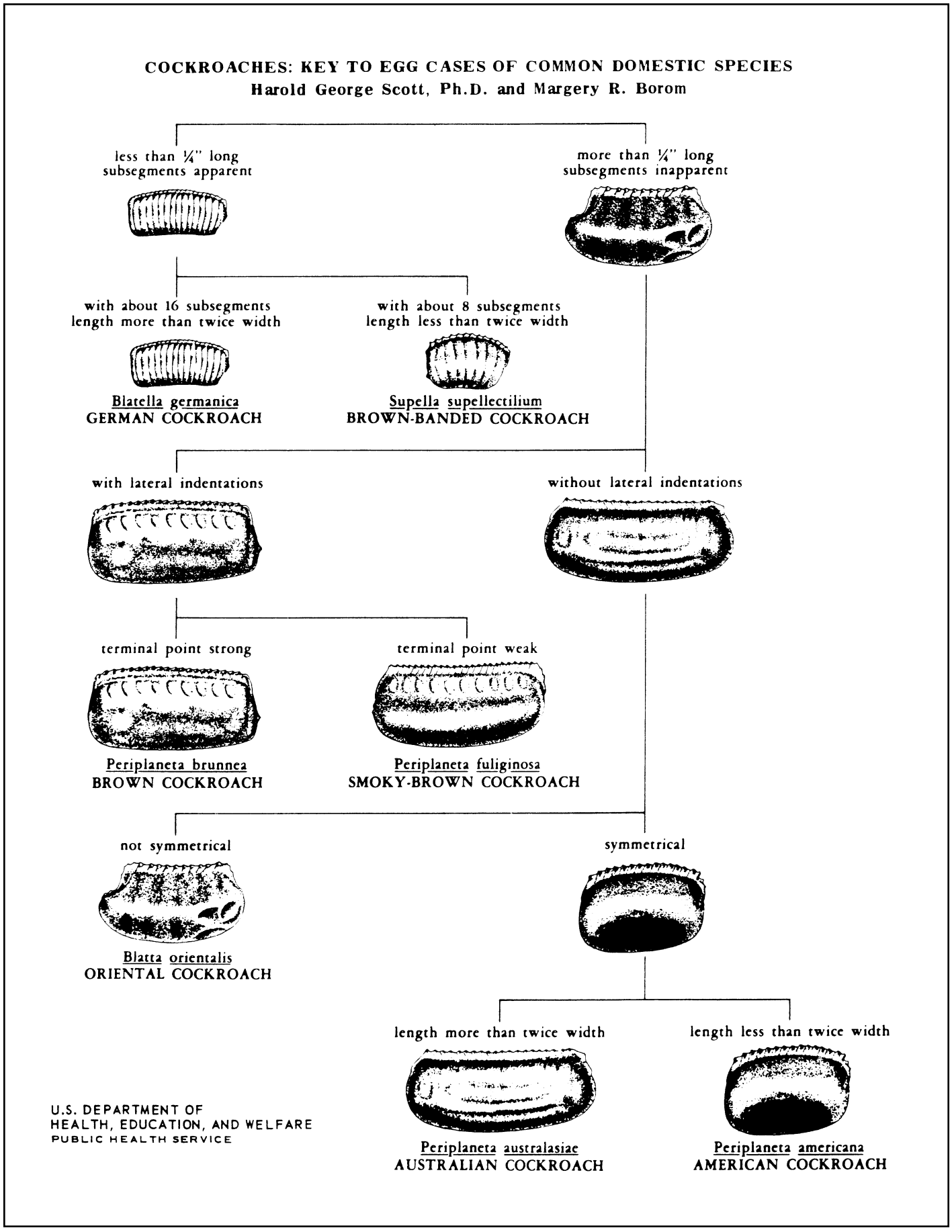


Figure 6.16. A pictorial key (from the CDC) of the egg cases of eight cockroach pest species.

SECTION 2 CHAPTER 6

Review Questions

Chapter 6: Cockroaches

Write the answers to the following questions and then check your answers with those in Appendix A in the back of this manual.

1-10. Match the following to the appropriate description.

A. German
B. Brown-banded
C. American
D. Oriental
E. Australian

_____ 1. The cockroach that requires the most control effort.
_____ 2. Two stripes on the pronotum.
_____ 3. Wings of the male extend slightly beyond the tip of the abdomen; female's wings do not.
_____ 4. Insect < $^{5}/_{8}$ inch, no stripes on pronotum.
_____ 5. Females are wingless.
_____ 6 Introduced on exotic plants.
_____ 7. Insect > $^{5}/_{8}$ inch; conspicuous markings on pronotum.
_____ 8. Egg cases > $^{1}/_{4}$ inch, if found in open areas, they indicate a large population.
_____ 9. Egg cases < $^{1}/_{4}$ inch, contain 30 to 40 eggs.
_____ 10. Egg cases < $^{1}/_{4}$ inch, glued in clumps under furniture, etc.

11. What do you tell a client who reports seeing albino cockroaches?

A. The cockroach population is probably low; the cockroaches are dying.
B. They are seeing nymphs that have molted.
C. They have found a rare specimen.
D. The cockroach population is probably large.
E. B & D

12. What causes cockroaches to leave areas of favorable harborage?

A. Population pressure
B. Intensive cleaning
C. Pesticide applications
D. A & C
E. All of the above

13. What is the purpose of aggregation pheromones?

14. How are sticky traps useful in managing cockroaches?

A. They can be used to indicate harborage locations.
B. They are effective at controlling cockroach populations.
C. They give an indication of the population size.
D. A&B

15. American cockroaches like an environment that is:

A. Slightly cool, moist.
B. Very warm, moist.
C. Hot, dry.
D. Moderately warm, average humidity.

16. Oriental cockroach populations consist mostly of _____ in the winter.

A. Adults
B. Nymphs
C. Eggs
D. Pupae

17. Cockroaches need _____ to be successful.

A. Food, moisture, harborage
B. Food, moisture, open spaces
C. Warmth, food, cracks
D. Cracks, crevices, food

18. Oriental cockroaches prefer a _____ environment.
    A. Moist
    B. Warm
    C. High
    D. Small

19. Brown-banded cockroaches prefer a ____ environment.
    A. Cool
    B. Very warm
    C. Sanitary
    D. Very moist

20. Which type of habitat alteration would be most effective against the American cockroach?
    A. Remove woodpiles
    B. Remove plants and treat elsewhere.
    C. Remove rotting leaves.
    D. B & C

21. Which type of control method would be most effective against the German and brown-banded cockroaches?
    A. Crack and crevice pesticide application
    B. Remove woodpiles
    C. Fogging
    D. Trap with sex pheromones

22. Match each cockroach with where it is MOST likely to be a pest problem.

A. Brown	_____	Tropical plants used in building interiors.
B. Smoky-brown	_____	Greenhouse plant feeder; Gutters and roof shingles.
C. Surinam	_____	Transported in plant soil; Sewers, crawl spaces, garages.
D. Woods	_____	Attracted to house lights.
E. Asian	_____	Brought in with firewood.

23. Which cockroach species consists only of female members in the United States?
    A. American
    B. Brown
    C. Smoky brown
    D. Brown-banded
    E. Surinam

24. For which cockroach species are pesticidal controls never required?
    A. Australian
    B. Oriental
    C. Smoky brown
    D. Woods
    E. Asian

25. List some non-toxic methods of controlling cockroach populations.

26. When using baits to control cockroaches:
    A. Always begin with thorough inspection to identify harborages.
    B. Completely fill cracks with bait.
    C. Always use a bait gun for large cockroach populations.
    D. Caulking to seal cracks is recommended.
    E. A & D

SECTION 2

CHAPTER 7

ANTS

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 a 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 dominant group of social insects related to bees and wasps. Except for the polar regions, they flourish on all land areas of the earth, from rain forests to deserts. All pest control technicians become involved with ant problems at some point in their career—most commonly because ants are found 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 mates with a male reproductive either during the swarming flight or on the ground. The male dies shortly afterwards. The female then digs or adapts a cavity, usually in the soil, and walls herself in. At this time, if her wings are not already broken off, she tears them off. She then produces eggs. When the tiny, white, legless grubs (larvae) hatch, they are fed with salivary secretions from the female's stored fat cells and the breakdown of her now useless wing muscles.

After several molts, the larvae change into soft, white pupae that look like motionless, white adults. Before they pupate, the larvae of some ants (carpenter ants and others) spin a silk cocoon—a white or tan papery capsule. When the pupae have made all the internal changes for adult functioning, they molt into the adult stage. Adults take on one of three roles or castes of the community: workers (all 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 make the colony. They may live many years.
- Workers, also females, tend the eggs, larvae, and pupae. They forage outside for food and enlarge and defend the colony workings.
- 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-sucking insects such as aphids, mealybugs (groups of small insects with a white powder clinging to them), scale insects, and planthoppers. These insects feed in groups on plant stems and leaves. Many species of ants protect these aggregations from other insects and take drops of the honeydew these small, sap-sucking individuals produce.

Some ant species appear to just wander randomly; others trail one another precisely from colony to food source and back. Ants communicate with one another using various methods for transmitting messages. 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 panics 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 a complete metamorphosis that is, they go through the egg, larva, pupa, and adult stages all of which look different from the others. Ant workers are adults.

  Termites have a gradual metamorphosis. They go through the egg, nymph and adult stages. Nymphs look like adult workers. Reproductives are dark-bodied.

- ***Ants*** have a thin or "wasp" waist (called the **petiole**) between their thorax and abdomen.

  Termite 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.

  Termite 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*** reproductives have two pairs of wings. The front pair is wider and markedly longer than the back pair. Often ants have a black dot near the tip of the front wings, and dark wing veins can be seen. Ant wings do not break off easily.

  Termite 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. Termite wing veins cannot be seen with the naked eye.

Figure. 7.1. Ant vs. termite reproductives.

ANT CONTROL AND MANAGEMENT

It is important to note that, of the ants found indoors, only a few species are responsible for the majority of infestations. Some species are not common but appear sporadically; and other types of ants are found inside only under rare or accidental conditions. The later group is difficult to prepare for, but the major species should be studied and discussed, and control experiences analyzed. Species that appear sporadically may take an inordinate amount of the pest controller's time, with inconclusive results. These elusive ants may appear several times in one year, then not be encountered for several years. Some are common in some regions and uncommon in others.

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

Size. Ant species have fairly consistent size.

Nodes. Nodes are swollen segments of the petiole (the narrow connection between the thorax and abdomen). Most species have one; others have two.

Color. Color may vary within the same species of ant, but it also can 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.

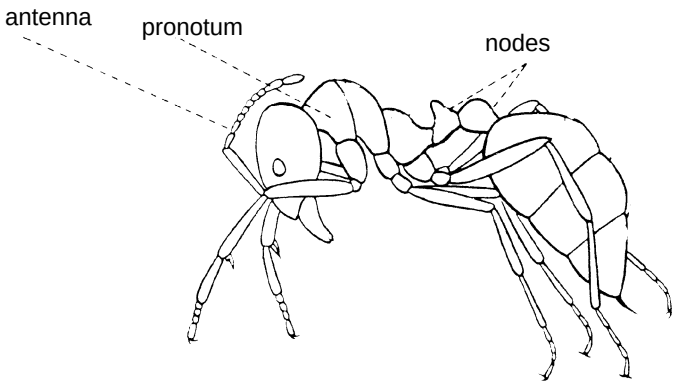


Figure 7.2. Identifying features of ants.

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:

- Ant workers are consistently found inside over a long uninterrupted period.
- Nest building is observed inside (look for wood shavings of carpenter ants, "dumping" materials of pavement ants, etc.).
- The infestation is located in a high-rise building.
- Inside swarming is observed.

Indications that a colony is outside are:

- Ants inside can be "trailed" outside.
- Ants outside can be seen coming inside.
- Nesting sites outside are near the infested structure (look for mounds next to the foundation, or trees with large carpenter ant colonies touching an infested portion of the house).
- 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 honeydew-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), ant colonies nearby put a great deal of energy into tending and protecting these plant-sucking insects. Worker ants foraging inside kitchens and basements often leave houses at this 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 because of natural habit.

The following general considerations are important in developing an ant control plan:

Inspection

- Talk to the client. Get all information possible from the resident.
- Observe ant worker movement and plot on a diagram, if need be. Look for the focus of the infestation.
- To confirm observations, use traps baited with a grease and a sugar or syrup or other ingredients suggested in pest control references (e.g., peanut butter and cookies).

Inside: Inspect holes and cracks where workers enter, old or new moisture stains, food accumulations (e.g., dry pet food), activity near appliances (e.g., dishwasher and washing machines), under bathtubs and showers, 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; near expansion joints, slabs, patio blocks, bricks, boards, and plant pots; under and inside wooden columns and pillars; outside door and window frames, in window wells; at places where electric and telephone wires, and air-conditioning refrigerant pipes penetrate house walls, in trees that harbor colonies and provide access to houses by overhanging limbs that touch or even scratch shingles; and among water meters and storm drain inspection manholes. Inspect plants for ants tending aphids, mealybugs, etc.

Habitat Alteration

Once you have determined where the infestation is coming from, use habitat alteration to block ant entry points or to make the environment unfavorable.

- Caulk wall penetrations and mortar masonry cracks. Wall penetrations include utility lines, air-conditioning refrigerant pipes, phone lines, etc.
- Tighten door and window frames.
- Repair water leaks.
- Remove food sources by regular cleaning (counters, floors, kitchen appliances, removing pet food, etc.) and keeping food in tightly sealed containers.
- Trim shrubbery away from house.
- Remove firewood that is stacked close to the house, and boards, stones, etc., that encourage nesting. Screen openings in hollow pillars, columns, and ventilators.

Pesticide Application

- Consider the species when choosing bait. Use baits with stomach poisons or with insect growth regulators. Baits are excellent in sensitive areas (e.g., computer or hospital rooms) where pesticide sprays are not appropriate. Do not spray or dust around baits. Never store baits or bait materials where they can be contaminated with any other odors, especially fumes of pesticides. ***Ants and other insects can detect minute amounts of foreign or repellant chemicals.***
- Use crack and crevice treatments in areas where nests are suspected. Use dusts in wall voids and use canned-pressurized liquid pesticides with small-diameter crack and crevice device. Tubing can be obtained in long lengths and can be threaded through construction elements to treat areas distant from the pressurized can.
- Control ant-tended aphids and mealybugs with horticultural pesticides, such as oils or soaps.
- Apply wettable powder or microencapsulated spray formulations where pesticides may be absorbed into surfaces.
- Drill holes where practicable (e.g., false floors in sink cabinets, window frames, wall panel grooves, and other voids).
- Use spot treatments when necessary, but be wary of repellant activity.
- Use granules and drenches with registered formulations 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.

Follow-up

Reinspect or contact clients with troublesome ant control problems within one week to ten days depending on the control strategies (baits and insect growth regulators [IGRs] take longer than dusts to show results). Remember, pesticide treatments can repel ants and make them active in other areas. Colonies with multiple queens may break up into several colonies.

LARGE ANTS (1/2 inch or larger)

CARPENTER ANT *(Camponotus* spp.*)*

There are many species of carpenter ants in North America; few enter structures to forage and fewer nest in structures. But these two habits (foraging and nesting inside), coupled with their large size and vigorous activity, make these invaders impossible to ignore. In Michigan, the black carpenter ant is the primary pest species. As their name implies, carpenter ants work in wood but do not digest it.

Figure 7.3. Carpenter ant, *Camponotus pennsylvanicus.*

BLACK CARPENTER ANT *(Camponotus pennsylvanicus)*

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 do not enter structures. Carpenter ants have an even, smooth, arching profile beginning just behind the head and descending 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 black carpenter ant's abdomen is covered with gray or yellowish hairs, but the basic black color is still obvious. The head and thorax is also black in the majority of individuals, but the sides of the thorax and part of the legs of a few may be dull red.

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 innumerable other secretive spots, but the colony soon moves into wood (such as a fallen log, tree hole, stump, or structure wall). When carpenter ant workers excavate nest galleries, they use their jaws as gouges and make tunnels by shaving out small pieces. Unlike termites, they do not eat the wood. It has no nutritional value to them, and they discard it by dropping it out of the nest area or by piling in one place and discarding the whole pile later (similar to the pavement ant's dumping habit). This pile of carpenter ant shavings, called sawdust, is very soft and is made up of pieces like those a fine chisel would make. Gritty construction sawdust in attics or on sills can be left over from construction or repairs and might suggest carpenter ant shavings to those who do not know the difference. The process of ant gallery excavation results in galleries with very smooth sides. No mud is involved (like in the tunnels of subterranean termites), and there is no dust or pellets (like those produced by wood borers or dry wood termites) only numerous large, smooth, brown-stained tunnels that provide harborage 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, but the colony more likely resides partially in structural wood and partially in void spaces (e.g., between roof boards, between studs under windows, or between subflooring and shower bases).

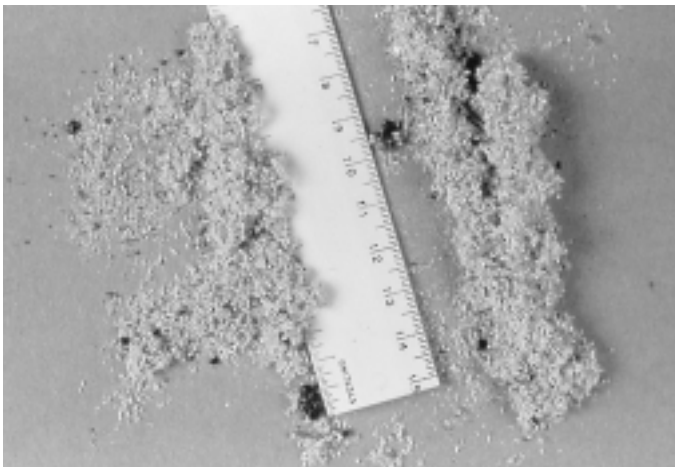


Figure 7.4. Carpenter ant shavings.

The most common outdoor harborage is a living tree with a rotted spot inside. Other common sites are stumps or firewood. The carpenter ant is a valuable link in the reduction of plant cellulose. It is not surprising that mature wooded neighborhoods often have structural carpenter ant problems. New neighborhoods or developments built on cleared woodlots can inherit ant colonies from trees. Some colonies are brought in with building

materials. Rustic cabins, summer homes, and park structures will likely become infested sooner or later.

Black carpenter ant workers forage for food such as honeydew, insects, and juices from ripe fruit. 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

Inspection

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

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

Moisture problems and black carpenter ants are nearly inseparable. In the majority of cases carpenter ants make their nests in wood that has been wet and infested by a brown rot fungus. Dark fungus stains on the wood indicate the presence of such moisture. Moisture in wood can be 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 as well as back onto roof boards, fascia, 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 (especially shower drains).
- Unvented attics and crawl spaces.
- Unvented dishwashers, washing machines, icemakers, etc.

The many nesting sites, foraging entrances, and food and moisture sources offer clues for inspection and location of the nest. 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 may be helpful.

Habitat Alteration

- Where nests are located inside, remove and replace infested structural wood.
- Stop the intrusion of moisture.
- Caulk and screen actual and potential ant entryways.
- 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.

Pesticide Application

Eliminating colonies and nesting sites is a primary way to eliminate carpenter ant infestation.

- Use pesticidal dust or pressurized canned aerosols when nests are in wall voids. Sprays are less effective.
- With the use of ***flushing agents,*** hundreds of ants may remain unaffected and can relocate the colony in a matter of hours or less to trunks, storage boxes, furniture drawers, and other voids.
- When indirect treatment is required, liberal placement of acceptable bait stations can be used.
- Dust, spray, or bait can be used on outside colonies (e.g., in tree rot).
- Professionals should evaluate trees with rotted places.
- Honeydew-producing insects involved in feeding carpenter ants should be treated with pesticides that will not eliminate parasites and predators (e.g., oils and pesticidal soaps).

Follow-up

Carpenter ant infestations often cannot be controlled in one visit. Painstaking inspection is needed to make management effective. Annual follow-up also assures that necessary habitat alterations have been made by clients.

Maintain records of all inspection discoveries and subsequent recommendations as well as records mandated by law.

SMALL- TO MEDIUM-SIZED ANTS (1/8 to 1/2 inch long)

ACROBAT ANTS *(Crematogaster* spp.*)*

Worker ants measure around $^1/_8$ inch long. The ant has two nodes; it is shiny brown to nearly black. The workers appear to have their abdomens attached upside down: flat on top, "bellied" below, and pointed at the tip. When they are excited, they point their abdomens up or even over their heads—hence their name. Acrobat ants are common over most of the United States. There are many species.

Acrobat ants tend aphids and mealybugs for honeydew and also feed on other insects. They usually establish their colonies in or under rotting logs and stumps in nature and sometimes live in abandoned carpenter ant galleries if the wood is damp enough. They can also

engrave their own small galleries in wet roof boards, house siding, porch rafters, pillars, sill plates—any part of a structure where the wood does not completely dry out. Like pavement ants, acrobat ant colonies occasionally dump their refuse. It consists of tiny wood shavings like those of the carpenter ant. The difference between acrobat ant and carpenter ant shavings is that those of the acrobat ant are smaller and always dark-stained from fungus. Acrobat ants may feed inside in kitchens.

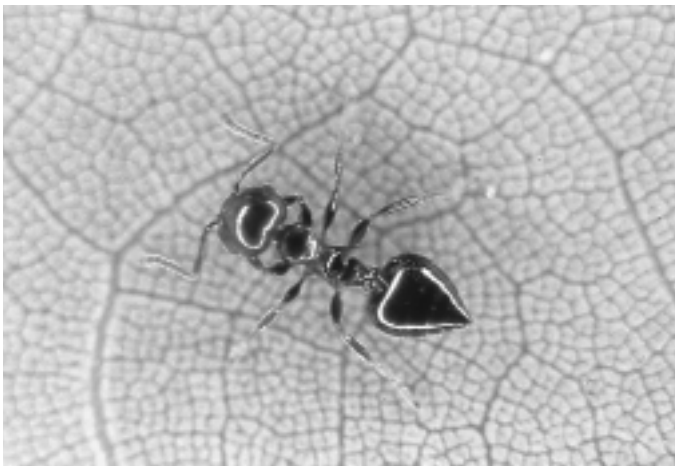


Figure 7.5. Acrobat ant, *Crematogaster* spp.

Control and Management of Acrobat Ants

Inspection

Look where structural wood has been subjected to water leaks:

- The porch roof near the house, porch floors, siding where gutters overflow, ends of rafters in the shade, sills, and window and door casings where rain water hits.
- In older buildings and historical buildings that haven't been kept up. (Fungus or rot problems are very likely more important here than ant damage.)

Habitat Alteration

- Remove and replace damaged wood.
- Change grade and redirect downspouts that pitch water toward structural wood.
- Clean or replace gutters.
- Trim overhanging tree limbs that keep wood from drying.
- Move logs, stumps, leaves, and grass clippings away from structures.

Pesticide Application

Habitat alterations will usually stop the problem. Use contact sprays if needed.

Follow-up

Susceptible structures, especially buildings with historical significance, should always be periodically monitored. Detailed records on pest infestations, treatments, and repairs should be kept on file.

SMALL ANTS (1/8 to 1/4 inch long)

In this group of ants, the workers are larger than the tiny ants but under $^1/_4$ inch in length. Several interesting structure-infesting ants are in this group.

PAVEMENT ANTS *(Tetramorium caespitum)*

This ant is found in cities in the Midwest. Around $^1/_8$ inch long, the pavement ant has two nodes. It has a shiny abdomen but a dull red-brown head and thorax; the abdomen is darker; legs are lighter. The red-brown head and thorax are dull because of minute, parallel furrows found on the front and sides.

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.

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 drop debris over the side in 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 source, householders often view these dumps with alarm.

A closely related species with good trailing habits and rapid movement is commonly introduced with tropical plants and flourishes in warm moist environments.

Figure 7.6. Pavement ant mounds.

Control and Management of Pavement Ants

Inspection

- 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.

Habitat alteration

- Remove stones that are sheltering ants.
- Recommend indoor sanitation, including the elimination of moist garbage in dry weather.
- Caulk observed ant entrance points.

Pesticide Application

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 door jambs.

Outside:

- Treat nests. Use pressurized gas aerosols to penetrate nest galleries.
- Treat cracks and entry points.

Follow-up

Follow-up is usually not needed, but where control is not achieved, an intense inspection is indicated.

TINY ANTS (1/8 inch or less)

ODOROUS HOUSE ANTS *(Tapinoma sessile)*

This ant, slightly broad, measures around $^1/_8$ inch long. It has one node, is dark brownish gray and covered with a velvety sheen. It can be found from Canada to Mexico including all of the lower 48 states. It is one of the more difficult ants to control.

The body of the odorous house ant is relatively soft and can be easily crushed. When this occurs, a foul odor is released. The single node of the petiole is very small and hidden by the overlapping abdomen. This identifying characteristic is best seen by crushing the soft ant and with a good hand lens noticing the absence of a distinctive node. From above, the abdomen is broad compared with the width of the thorax.

An average colony will have 3,000-4,000 members and several queens. Outdoor nests are shallow and are located under stones and boards. Inside, a colony can nest in many types of cavities.

The workers trail one another. Outside, they actively tend honeydew-producing insects and take flower nectar. Inside, workers seem to prefer sweets.

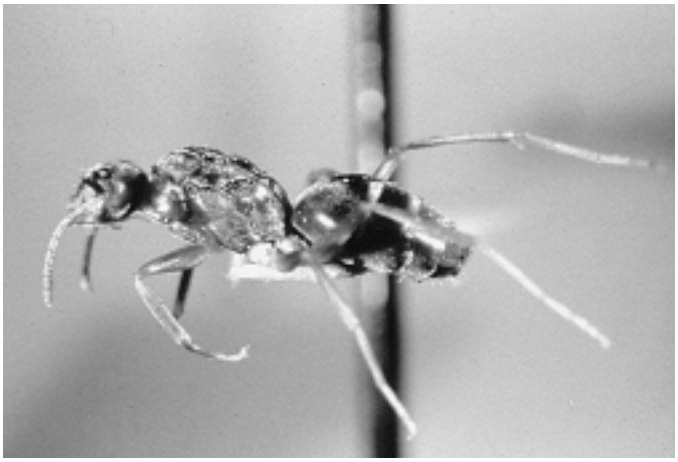


Figure 7.7. Odorous house ant, *Tapinoma sessile*.

Control and Management of Odorous House Ants

Inspection

- Begin by investigating locations where ant activity is observed.
- Pyrethrins can flush ants, causing them to rush around erratically, excitedly elevating their abdomens. This could cause the colony to split itself and relocate.
- Always inspect outside close to the location of inside activity. Look under stones and boards for colony openings and activity.

Habitat Alteration

- Remove stones and boards harboring odorous house ant colonies.

Pesticide Application

- Use dusts or residual sprays applied in cracks and crevices in the area of entering worker trails. Any ant 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 its locality inside precludes its 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.

Follow-up

Emphasize to the client the need to control honeydew insects on plants and to eliminate nest harborage near structures. Keep in mind that it is a very difficult ant to control.

PHARAOH ANTS *(Monomorium pharaonis)*

A tiny ant, not much more than $^{1}/_{16}$ inch long, the pharaoh ant has two nodes. Its head and thorax are dull yellowish to light orange or a little darker. It has a shiny dark abdomen, especially at the end.

It is found in most urban centers in the United States. Pharaoh ants prefer warmer buildings and warm areas (80 to 85 degrees F) in buildings for nesting. These ants are active year round in houses and portions of large buildings such as hospitals, office 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—one portion of the colony goes with each queen. No swarms have been recorded, so new infestations are apparently transferred by moving infested objects.

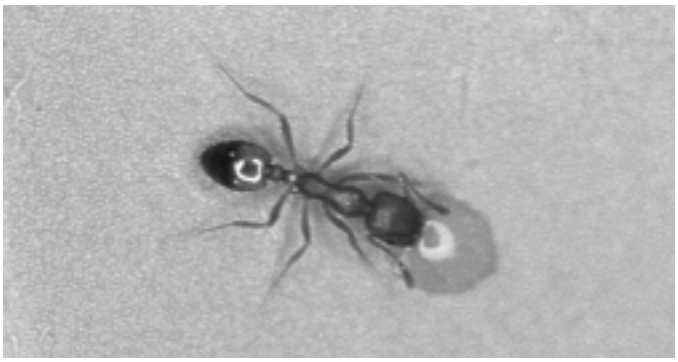


Figure 7.8. Pharaoh ant, *Monomorium pharaonis*.

Pharaoh ants trail one another and are attracted to grease, meats, insects, and sweets. These 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.

Figure 7.9. Pharaoh ants—male, queen, and worker.

Control and Management of Pharaoh Ants

Inspection

- Inspect where sanitation is slipping or where food is available, particularly sugars—where coffee is made, where lunches are eaten, in desks where snacks are stored.
- Inspect storage room spills, laboratory media, culture and formula preparation rooms, nurses' stations, unwashed cups, coin machine canteens, and kitchens frequented by children.
- Use small disposable peanut butter-baited cups to demonstrate where ants are most prevalent (e.g., desk drawers, opened food boxes). 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.

Habitat Alteration

- Reduce stored supplies.
- 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.

Pesticide Application

Several baits are available for pharaoh ant control. Place a bait station wherever a positive monitoring trap was located.

- Set commercial bait stations. One type uses a stomach poison that is well accepted by ants and a grain-based bait that includes ground insect exoskeletons. This bait is specifically manufactured for pharaoh ant control. These bait stations can be placed in desks and used in hospital rooms and laboratories.
- Use a mixture of liver extract (or strained-liver baby food), angel food cake, and honey or syrup with a registered growth regulator or boric acid powder. This bait can be placed in small cups or screened vials or injected into cut drinking straws using a food baster. Mix to a usable consistency.
- Use a commercial preparation of mint apple jelly and boric acid; ingredients can also be purchased separately and mixed. Place the preparation on pieces of masking tape for easy retrieval.
- Apply sprays or dusts in cracks and crevices when preferred. All potential harborage near positive monitoring locations should be treated thoroughly.

Follow-up

Reinspect by monitoring bait cups. When sprays or dusts are used, or when colonies are disturbed by inspection or habitat alteration, colonies may move or split.

LITTLE BLACK ANTS *(Monomorium minimum)*

This little ant is no more than $^{1}/_{16}$ inch long. It has two nodes and is shiny black. The ant is widely distributed in the United States especially in the northern and eastern states, and in southern Canada. It normally nests outdoors and tends honeydew-producing insects.

THIEF ANTS *(Solenopsis molesta)*

Less than $^{1}/_{16}$ inch long, the thief ant has two nodes and is shiny with a yellowish or slightly darker color. It is widely distributed throughout the United States, especially in the eastern and southern states. The thief ant nests both inside and outside and tends honeydew-producing insects.

USING BAITS TO CONTROL ANTS

Baits are a very effective tool for managing ant problems, especially for pharaoh ants or when a nest may be hard to find (as is often the case with thief ants). The food source will contain a sweet or protein/fat base, or a combination of both, mixed with a slow-acting poison. Workers will carry the materials back to the nest and feed the larvae, other workers, and the queen. Some tips on using ant baits successfully are:

- Correctly identify the ant species. Some ant species are less inclined to enter bait stations than others. Some ants prefer baits that contain sweets or dead insects (e.g., field ants), while others prefer a protein base (e.g., pavement ants).
- Clean up any spilled food and place any accessible food in airtight containers (other food sources compete with bait material).
- Keep baits in protective overwrap until ready to use. Baits should be stored separately, away from other chemicals, to avoid contamination.
- Wash hands thoroughly and wear clean gloves when handling baits.
- Allow time for baits to work (7 to 14 days for normal colony elimination). There may be a surge in ants after 2 to 3 weeks because of new emergence from pupae. Rebait as required.
- Replace baits every 3 months or less. Ants won't be attracted to stale baits.
- Place additional baits to ensure adequate coverage. Emptied bait stations are a sign that not enough baits have been placed.
- Place bait stations where activity is greatest.
- Consider using alternate baits (ants sometimes change their feeding preferences).
- Check into the history of pesticide use. If residuals have been used, clean up residues with dish detergent and water prior to bait placement. Instruct the client not to spray or fog once baits are placed. Ants are extremely sensitive to chemical residues and will avoid bait stations if they detect any.

SUMMARY

Ants are the dominant group of social insects. Their relatives are bees and wasps, some of which also have social habits. All of these insects undergo complete metamorphosis. Ants have three principal castes: the female reproductives, the male reproductives, and female workers. Each caste has different tasks and behavior. Ants, being social, live in colonies. A single female starts the colony after being fertilized by males. Most of the offspring of this female (often called the queen) are also female and they do the work of the colony, such as food gathering and rearing the young (larvae and pupae). Many ants tend insects that suck plant sap and produce a liquid (honeydew) that ants eat. Many species also have a broad diet, feeding on other insects, sugars, and greases; their habits may change seasonally. Most ants have subterranean colonies and do not enter buildings, but some can live outside or set up their colonies inside. One species, the pharaoh ant, lives inside almost exclusively. Knowing the behavior of the common ant species will help to decide the control measures needed to suppress pest ants

SECTION 2 CHAPTER 7

Review Questions

Chapter 7: Ants

Write the answers to the following questions and then check your answers with those in Appendix A in the back of this manual.

1. Ants and termites are both closely related social insects.

   A.True

   B.False

2. Ants found inside a structure always come from a colony that is located inside.

   A. True

   B. False

3. Carpenter ants make galleries in wood, which is also one of their principal foods.

   A. True

   B. False

4. The ant caste system consists of :

   A. Workers, drones, soldiers

   B. Soldiers, workers, reproductives

   C. Male and female reproductives and workers

   D. Larvae, pupae, adults

5. Indicate whether the following statements are characteristic of ants or termites.

   A. Ant _____ Front pair of wings is wider and longer than the back pair

   B. Termite _____ Have "petiole" between thorax and abdomen

   _____ Young are nymphs

   _____ Undergo complete metamorphosis

   _____ Thorax and abdomen blend together; not narrow

   _____ Wing veins not visible with the naked eye

   _____ Leave many broken wings in swarm area

   _____ Have elbowed antennae

6. Ants forage for _____ to sustain themselves and the colony.

   A. Honeydew, greases, sugars, and insects

   B. Wood

   C. Honeydew alone

   D. Pheromones

7. Which ant species almost always has its colony inside?

   A. Carpenter ant

   B. Pharaoh ant

   C. Pavement ant

   D. Odorous house ant

8. List at least four means of altering ant habitat to discourage ants from invading a building.

9. When using insecticides to control ants:

   A. Place baits, then spray around them.

   B. Crack and crevice can be used to treat areas where nests are suspected.

   C. Store baits safely with other pesticides.

   D. A & C

   E. B & C

10-18. Match the following to the appropriate description.

A. Carpenter ant
B. Acrobat ant
C. Pavement ant
D. Odorous house ant
E. Pharaoh ant

_____ 10. Common problem in hospitals.

_____ 11. Point abdomens up or over their heads when excited.

_____ 12. Soft bodies, easily crushed.

_____ 13. Average colony numbers 3,000 to 4,000 members.

_____ 14. Live in trees with rotted areas inside.

_____ 15. Sometimes live in abandoned carpenter ant galleries.

_____ 16. Debris is found dumped from foundation walls to the basement floor.

_____ 17. Often considered a problem in historical buildings.

_____ 18. Produce wood shavings that are smaller than those made by carpenter ants and always dark-stained from fungus.

19. If the carpenter ant colony is found outside but the ants are a problem inside the building, advise the client to:

A. Use pressurized canned aerosols in wall voids.
B. Trim trees where branches overhang or touch roofs.
C. Use a flushing agent to determine extent of infestation.
D. Caulk and/or screen to prevent ant entryways.
E. B & D

20. Which would be the "best" method for controlling the odorous house ant?

A. Stop the intrusion of moisture into wood.
B. Treat cracks along foundation walls.
C. Control populations of honeydew-producing insects on plants.
D. Clean gutters.
E. A & D

21. Which would be the "best" method for controlling pharaoh ants?

A. Set several bait stations.
B. Treat cracks along foundation walls.
C. Control populations of honeydew-producing insects on plants.
D. Clean gutters.
E. A & D

22. Which would be the "best" method for controlling acrobat ants?

A. Set several bait stations.
B. Treat cracks along foundation walls.
C. Control populations of honeydew-producing insects on plants.
D. Clean gutters.
E. A & D

23. Which would be the "best" method for controlling pavement ants?

A. Set several bait stations.
B. Treat cracks along foundation walls.
C. Control populations of honeydew-producing insects on plants.
D. Clean gutters.
E. A & D

24. For which ant species would altering the habitat by removing or replacing damaged wood be an effective control?

A. Carpenter
B. Acrobat
C. Odorous
D. Pharoah
E. A & B

25. Baits are effective at controlling ants within 3 to 4 days.

A. True
B. False

26. Use different baits for different ant species.

A. True
B. False

SECTION 2
CHAPTER 8

STORED-PRODUCT AND FABRIC PESTS

LEARNING OBJECTIVES

After completely studying this chapter, you should be able to:

- Identify common stored-product and fabric pests.
- Identify factors that contribute to pest infestations 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.
- Discuss pest management procedures for stored-product and fabric pests.

Stored-product pests include weevils, beetles, and moths. Fabric pests consist of beetles 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 are the best defenses.

STORED-PRODUCT PESTS

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.

The most commonly attacked products are cereal grains, spices, and nuts. Less commonly attacked are dried fruits, candy, rodent bait, dried dog food, dried decorative flowers, and such diverse materials as museum artifacts, cosmetics, and drugs. Old, neglected, or hard-to-reach products provide the greatest potential for infestation and reinfestation.

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.

- All inspections should be conducted with strong flashlights. A knife, a good hand lens, screwdrivers, and mirrors are also useful equipment.

- Flushing agents can be used, but care must be taken not to contaminate foodstuffs.
- Special attention should be given to all spills. Check for pests, cast skins, and tracks in spilled products or dust.
- Inspect the backs of pantry shelves, floors under shelves, and all dark areas.
- Pheromone traps, available for nearly all stored-product pests, should be used 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. Use bump hats and be careful of heat machines and electrical hazards.

Habitat Alteration

- Institute a regular and thorough cleaning program. Pesticide use without routine cleaning will not control stored-product pest infestations.
- Caulk cracks (especially wall penetrations) that communicate 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.
- Recommend storing materials that are not commonly infested (e.g., animal bedding, paper products, canned goods) away from infestible products.
- Discard infested materials. Sanitation is the primary method of population reduction where infested stored products are found.

Pesticide Application

- Pesticides registered for use in the infested area should be carefully applied to cracks and crevices.
- Apply spot treatments only in areas where there is an obvious and immediate need to kill migrating insects.
- Install insect electrocuters properly to attract flying insects.
- Investigate pheromone trapping for killing in conjunction with other methods.

Follow-up

On-going monitoring and inspection plans should be put into effect in all food-handling establishments. A complete pest management program is recommended for these operations. Clear communication with clients is important. Recommendations on cleaning and sanitation should be continually evaluated.

PESTS OF WHOLE GRAINS AND SEEDS ("primary" pests)

Most stored-product pests feed on the readily available starch of broken or ground-up seeds and grains. Few species can chew through the strong seed coat or place eggs inside intact grains. Pests that can are the rice and granary weevil, the Angoumois grain moth, the lesser grain borer, several species of seed beetles, and pea and bean weevils in the family Bruchidae.

RICE WEEVILS AND GRANARY WEEVILS (*Sitophilus oryzae* and *Sitophilus granarius*)

These two similar snout beetles are found in stored whole grains throughout the United States. Adult beetles have snouts with jaws (mandibles) at the tip. With these jaws, females chew holes in the grain and deposit eggs. Larvae devour the inside of the seeds, pupate, and emerge as adults to renew the cycle. **Rice weevils,** common in the southern states, can fly. **Granary weevils,** more common in cooler climates, cannot fly. These two weevils are more common in granaries and mills than in stores and homes, but they infest a wide variety of cereal grains and seeds that are found in storerooms, pantries, garages, and other storage sites. The word "weevily" is still used in general reference to infested grain products, whether or not the infesting pest is a weevil.

Another weevil with a much longer snout infests acorns, pecans, and hickory nuts. **Acorn weevil** larvae leave the acorns and nuts to pupate. When infested nuts are brought inside, fat white larvae often escape and wriggle across tables, floors, etc.

Figure 8.1. Rice weevil, *Sitophilus oryzae.*

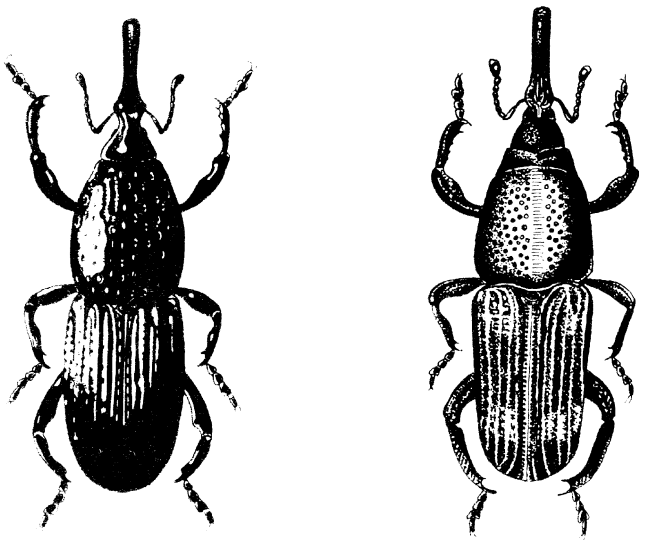


Figure 8.2. Granary weevil, *Sitophilus granarius* (left), and rice weevil, *Sitophilus oryzae* (right).

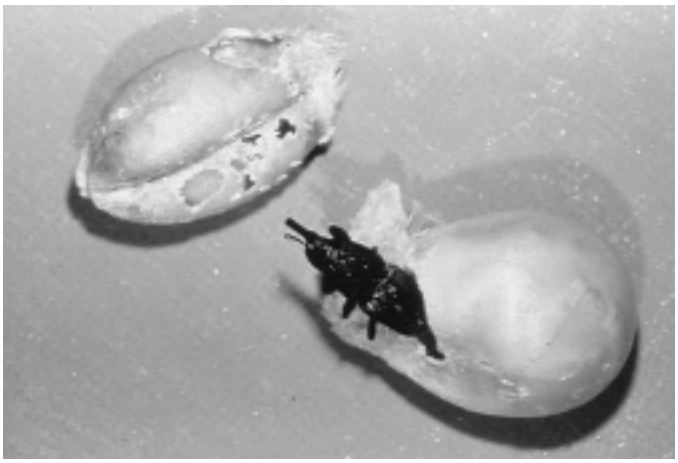


Figure 8.3. Weevil emerging from seed.

ANGOUMOIS GRAIN MOTH *(Sitotroga cerealella)*

This buff, tan, or golden moth, with a wing span of ½ inch, is larger than the common golden-colored clothes moth. With wings folded, it is more than ¼ inch long. The Angoumois grain moth is most commonly found in whole corn in the South and Midwest. Like the weevil, it is more often a problem in grain storage. But if whole corn is brought into homes or stores, sooner or later these moths are likely to become pests and fly about.

LESSER GRAIN BORER *(Rhyzopertha dominica)*

A small, cylindrical brown beetle about ⅛ inch long, this beetle is an important damaging pest of grain in storage or transport (trains, ships, etc.). Like many of its relatives (the Bostrichids, most of which are wood borers), the lesser grain borer has strong jaws that can chew through seed coats into grain, where it completes its life cycle. This beetle is rarely a problem in urban homes or stores.

SEED BEETLES OR PEA AND BEAN WEEVILS

These beetles are not true weevils and do not have the weevil snouts. They belong to the seed beetle family Bruchidae. They infest only the seeds of one large plant family, the legumes: peas, cowpeas, and most beans (including mung beans). Each of these pests specializes in one kind of seed.

Most species measure ⅛ to less than ¼ inch long. They are rather broad and have light and dark markings. They lay eggs on beans. Larvae bore inside, devour the middle, and then emerge through obvious ⅛-inch holes. The pest can be a problem in restaurants and homes. Infested and potentially infested legume seeds should be discarded.

Figure 8.4. Bruchid beetle—seed beetle, pea, or bean weevil.

Figure 8.5. Cowpea weevil, family Bruchidae.

PESTS OF GROUND, MILLED, OR PROCESSED GRAIN, SPICES, SEEDS, AND NUTS ("secondary" pests)

This large group of pests (some are called "bran bugs") infest stored products that have seed coats that are broken or removed by processing. Potential infested products are listed with each species.

INDIAN MEAL MOTH *(Plodia interpunctella)*

The Indian meal moth is a small, colorful moth that is 1/3 inch long (somewhat longer with wings folded backward). The head and thorax are brown. The basal half of the wings are gray, and the last half is coppery with dark bands. These moths can fly short distances indoors. Active flight for several days wears off most of the colored scales, but the gray band and coppery scales can be seen using a hand lens.

Larvae (caterpillars) grow to be about 1/2 inch long and are cream-colored (sometimes pinkish or greenish) with brown heads. Though they are not easily seen, fairly long hairs grow sparsely on each larval segment. When the larva is in a dusty environment, small particles will stick to the hairs. The Indian meal moth's life cycle is about two months.

Infestations in packaged products start with small numbers. The longer the product is kept without use, the larger the population grows. Larvae spin silk from their lower lip wherever they go. In large numbers, they can cover the top of a product with silk as they wander around on the surface. As a population grows, larvae may wander outside the package (often for long distances: from a room in lower levels, through holes in the floor into upper areas, from a pantry to the ceiling). They may dangle from ceilings on silk strands. Their numbers, wandering habits, and large size easily distinguish Indian meal moth larvae from the tiny clothes moth larvae, which do not wander openly. A pheromone that specifically attracts the flying Indian meal moth is a very effective monitoring tool to use in warehouses and food service or retail food stores. In large areas, pheromone trap results reveal infested areas.

Indian meal moths infest most milled or ground cereals such as flour and cornmeal, and all starchy processed products such as crackers, cake mixes, pasta, dog food, and rodent bait. They particularly respond to nutmeats such as pecans and walnuts, nuts in candy, powdered milk, some spices, and dried fruit. Products stored or unused for a long time are always primary suspects for infestations.

Control and management of these pests is the same as that for the saw-toothed grain beetle.

Figure 8.6. Indian meal moth, *Plodia interpunctella.*

Figure 8.7. Indian meal moth larvae.

SAW-TOOTHED GRAIN BEETLE *(Oryzaephilus surinamensis)*

The saw-toothed grain beetle is a tiny, slender, dark brown beetle that measures a little under 1/8 inch long. With a good hand lens, a pesticide applicator can identify three ridges that appear as fine lines on top of the thorax with six fine teeth on either side. Eggs are deposited on infested food and hatch into tiny, white larvae.

At full growth, larvae are slightly smaller than the adults. They become covered with the material they infest and appear to be very small lumps. Pupae are equally inconspicuous. Larvae do not leave the infested material. Adults do, and though they do not fly, they wander in conspicuous numbers in the same vicinity as the infested material. A similar species is the merchant grain beetle.

Little harborage alteration is indicated. Older products will produce large populations simply because more generations develop over time. Saw-toothed grain beetles infest the same materials as the Indian meal moth. Likewise, finding the infested product and cleaning the area of infestation is of prime importance. Cockroach bait stations with a grain base may be useful

in attracting and killing these beetles. Capture in these bait stations may be the first indication of beetle infestation. Pesticide sprays are not needed if infested material is discarded and cracks and crevices cleaned. Follow-up normally is not needed.

Figure 8.8. Saw-toothed grain beetle, *Oryzaephilus surinamensis.*

CABINET OR WAREHOUSE BEETLES (*Trogoderma* spp.)

In the same family as carpet, hide, and larder beetles (see "Fabric Pests"), Trogoderma and closely related species (cabinet, larger cabinet, and warehouse beetles) principally infest grain-based products. One species, the Khapra beetle, is a very serious grain pest. Routine federal quarantine inspections are made to prevent its entry and establishment in the United States. It has been known to build up in large infestations.

Trogoderma adult beetles range from $^1/_{16}$ inch to about $^1/_4$ inch in length. They are about half as wide as long, which gives them an oval appearance. Their base color is black with three reddish brown, golden, or gray irregular lines across the body. Larvae are stout and capsule-shaped. Their segments are seen as stripes across the body.

Figure 8.9. Adult beetle, *Trogoderma* spp.

Figure 8.10. Beetle larva, *Trogoderma* spp.

Species that infest processed grain can be found in warehouses, storage rooms, and homes. These beetles commonly infest cereal, spices, rodent bait, dry dog food, wheat germ, and other processed cereal products with a high protein content.

Control and Management of Cabinet or Warehouse Beetles

Inspection

- Give special attention to products with a long shelf life, such as dry animal food. Large pest populations can build up because more attention is given to the rotation of more perishable products.
- Make extensive inspection to locate all infested material.

Habitat Alteration

- Advise intensive cleaning of warehouses and storage rooms.

Pesticide Application

- Limit use of pesticides registered for food areas to application in cracks and crevices.
- Fumigate mills or warehouses as needed.

Follow-up

Set up regular monitoring programs in warehouses and food-storage areas. Pheromones for stored-product beetles are very helpful in such programs.

CIGARETTE AND DRUGSTORE BEETLES *(Lasioderma serricorne and Stegobium paniceum)*

These beetles are similar in appearance. They are related to some wood borers or powderpost beetles, but their habits are quite different. Adult cigarette and drugstore beetles are oval, about $^1/_8$ inch long and reddish brown. They can fly. The cigarette beetle is covered with tiny hairs that give it a golden sheen. The drugstore beetle appears dull and darker because of deeper lines on its wing covers.

Larvae are tiny, white, curved, and covered with infested material—they look like tiny lumps of the stored product. They are difficult to detect unless the product is dumped and sifted.

These beetles are commonly found in spices (paprika, ground pepper, ginger), milled cereals (flour and cornmeal), dry dog food, cosmetics, drugs, as well as some human poisons, pyrethrum dusts, and dried flowers (through the glue that attaches the flower head to wire stems). In homes, spices are favorite foods, especially paprika.

Locate the infested material (beginning with spices) and discard all infested products. Follow-up is seldom needed.

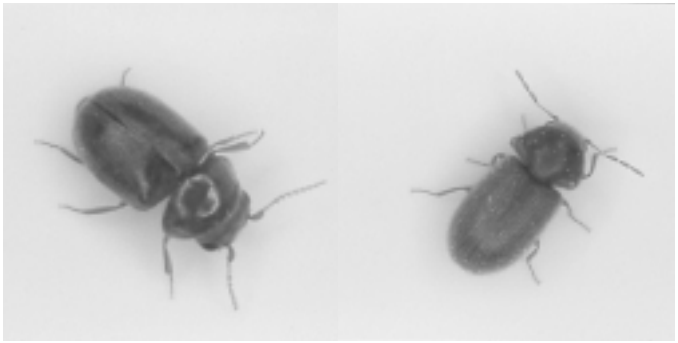


Figure 8.11. Cigarette beetle, *Lasioderma serricorne* (left) and drugstore beetle, *Stegobium paniceum* (right).

FLOUR BEETLES *(Tribolium castaneum* and *T. confusum)*

Two common species of flour beetles infest dry milled cereal products in flour mills, retail food stores, and homes. Other closely related species are found from time to time, but the two that are best known are the red flour beetle and the confused flour beetle. These beetles are about 1/8 inch long and reddish brown with short, stout antennae. Larvae are slightly longer than adults, creamy white, with few hairs.

Only those flour mills with the most thorough cleaning programs keep populations of flour beetles low.

Figure 8.12. Red flour beetle, *Tribolium castaneum.*

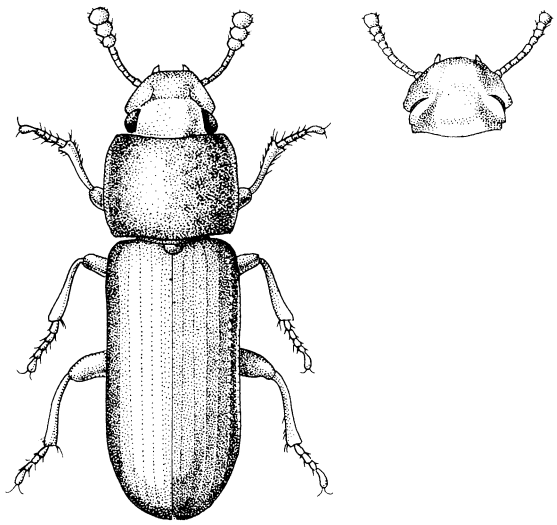


Figure 8.13. Confused flour beetle, *Tribolium confusum* (left), and red flour beetle, *Tribolium castaneum* (right).

These beetles can live on flour spills. Packaged milled cereals such as flour, cornmeal and cake mixes bought in large quantities may be stored long enough to allow eggs or larvae that have slipped through the milling and packaging process to develop.

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, and that older packages be discarded if use is not planned.
- Follow-up in homes is usually not needed. Retail food stores and warehouses should have on-going monitoring programs.

SPIDER BEETLES

A number of species of these small, oval beetles are scavengers on stored products. Spider beetles range in size from less than $\frac{1}{8}$ inch to nearly $\frac{1}{4}$ inch. They have long legs and antennae. The abdomen is usually oval and much larger than the head and thorax combined. Most species have short hairs covering the thorax and wing covers. Several common species have shiny, hairless, globular wing covers that make them look like spiders.

Spider beetle larvae are white and grub-like. Pupae are enclosed in silk cases covered by the materials they infest. They look like lumps of the stored product.

The variety of foods they infest ranges from flour, cornmeal, and all broken cereal grains to fish meal, seeds, spices, dried fruit, and dog biscuits. In museums, they infest skins, hair, wool, feathers, textiles, insect specimens, leather goods, brushes, and wooden artifacts. Other materials include soap, rat and mouse droppings, mammal and bird nests, and decaying animal and vegetable refuse.

Figure 8.14. Spider beetle.

Inspection

- Use sticky traps or cockroach monitors.
- When small infestations of spider beetles are found, search for their source.

Habitat Alteration

- Discard the product source; clean thoroughly.
- Eliminate all clutter and unused products.

Pesticide Application

- Apply spot treatments in cleaned, non-food areas.

Follow-up

A monitoring program using sticky traps should be followed until the population is eliminated.

PESTS OF MOLDY, DAMP, OR OUT-OF-CONDITION GRAIN AND GRAIN PRODUCTS

Milled or ground cereals and cereal-based products become heavily infested with fungi and bacteria when their moisture content is high. Many insects feed on the starches, proteins, certain vitamins, and other chemicals produced in the process of decomposition by microorganisms. Spoiled products may include animal foods, milled cereals, flour spills, and caked milled grain. Pests can be found in unclean grain storage elevators, barns, and mills, as well as in kitchen pantries and cabinets with moisture leaks or ineffective ventilation. The infesting pests are scavengers whose nutritive requirements are met by fungal-infested cereal products. They can develop into large populations. These pests include grain beetles, mealworms, and mites. Two merit special attention.

PSOCIDS

Psocids are tiny, pale gray or yellowish white, wingless, soft-bodied insects little more than $^{1}/_{16}$ inch long. They feed primarily on mold that grows on decomposing starchy materials. Psocids are sometimes called "book lice" because they are found in great numbers on books and papers sized with starch and stored in damp situations. Psocids require a minimal relative humidity of at least 60 percent. This level accomplishes two purposes: the moisture keeps the psocids from drying out, and it promotes the mold or fungal growth on which they feed. A relatively high humidity can be 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.

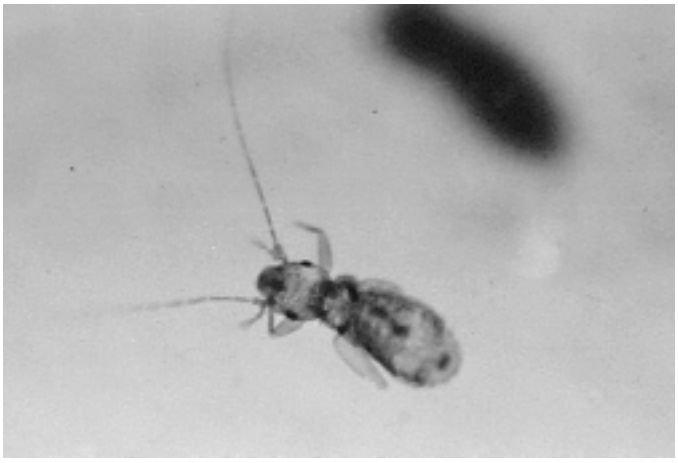


Figure 8.15. Book louse.

GRAIN MITES

The most common grain mite is called *Acaras siro.* These tiny tick relatives look like dust with a slightly brownish tinge. A constant humidity level is even more important to grain mites—they prefer relative humidities between 75 and 85 percent. Grain mites are almost colorless but have long microscopic hairs. When they molt, the hairs of the cast skins cling to those of others. They can pile up in a fluffy ball the size of a man's palm. A population of that size can be produced in a humid kitchen cabinet with as little as a scant dusting of flour over the shelf.

Like psocids, discarding infested materials and cleaning and drying out the chamber can eliminate grain mites. Grain mites are known to be responsible for allergies like those caused by house dust mites in humid homes. Use preparations containing tannic acid (carpet cleaners or brewed tea) applied to mite cast skins to suppress this protein allergy.

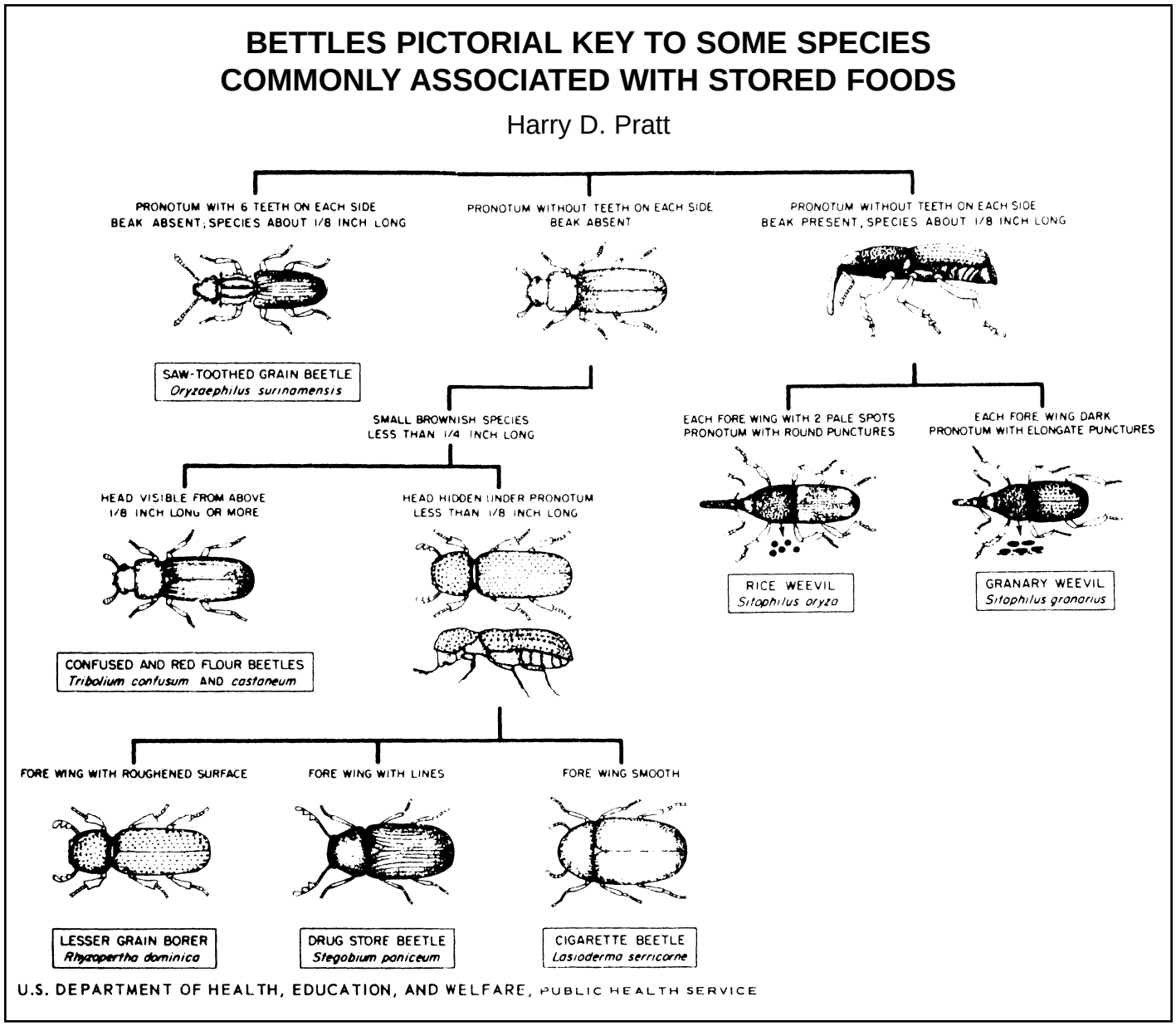


Figure 8.16. Pictorial key of common stored-product pest beetles.

FABRIC PESTS

Fabric, or textile, pest infestations sometimes present the most difficult problems a pest management technician can encounter. Except for fumigation, pesticide use alone is never an effective control for textile pest problems.

Textiles that are infested and consumed by pests are usually wool-based such as woolen clothing, carpets, and tapestries. Two types of insects are responsible for most woolen fabric damage, but by their nature, these pests—**carpet beetles and clothes moths**—feed on a broader diet than wool alone. Besides textiles made of processed wool, they feed on many other substances with a high protein content. One particular protein, keratin, is present in wool and other hair or fur. The same material is also found in feathers, skins, horns, and hooves. Other materials that are high in protein are insect bodies, pollen, silk, grains and seeds (particularly the "germ," as in wheat germ, or non-starchy portions). Insects are the only animals capable of digesting keratin. Only a few microorganisms and fungi in other kingdoms are keratin reducers.

Fabric pests—carpet beetles and clothes moths—developed as scavengers, consuming feathers, fur, and hides of dead birds and mammals. Many species feed on dead insects, the molted skins and pupal cases of moths, silkworms, tent caterpillars, mud daubers, yellow jackets, wasps, hornets, and dead bees, and pollen.

Textile pests are generally secretive and develop on food that decomposes slowly. As populations of textile pests increase, individual adults and mature larvae migrate away from the infestation to mate or pupate in protected solitude. This activity often is the only signal that a pest infestation is present. The four groups of carpet beetles and two species of clothes moths can be identified from specimens of either adults or larvae.

CARPET BEETLES

All species of hide and carpet beetles, along with the stored-product pests cabinet and warehouse beetles, belong in the beetle family Dermestidae. Adult beetles have short, clubbed antennae, are black possibly with yellow white or orange scales (observable only with a good hand lens), or covered with fine, smooth hair. The females can lay eggs throughout the year, although the adults tend to be cyclical and most active in spring. Adults commonly feed on flowers and flower pollen. The larvae are responsible for most textile damage. They can be long-lived. When food is scarce, larvae continue to molt for longer periods, waiting out a food supply.

HIDE AND CARPET BEETLES

Adults:

- The **larder beetle** *(Dermestes lardarius)* is large and oblong and will grow from 1/4 to 3/8 inch long. It has a dull, dark or black head and thorax, and its wing covers behind the thorax are half dull yellow, and on the latter half, black.
- The **hide beetle** *(Dermestes maculatus)* is large, oblong and 1/4 to 3/8 inch long. Its dorsal or top surface is dark brown or black, sometimes with white scales on the margin of the thorax. The undersurface is also covered with white scales.
- Some other species of *Dermestes* (e.g., the incinerator beetle and the leather beetle) resemble the hide beetle with similar habits.
- The **black carpet beetle** *(Attagenus unicolor,* also called *A. megatoma* and *A. piceus)* is oblong to oval. It is 1/8 inch long, dark brown or black, and not shiny.
- The **common carpet beetle** *(Anthrenus scrophulariae),* the **furniture carpet beetle** *(Anthrenus flavipes),* and the **varied carpet beetle** *(Anthrenus verbasci)* are about 1/8 inch long or less. They are mottled and covered with yellow, white, orange, and black, small, flat scales (visible with a good hand lens).
- **Warehouse and cabinet beetles** *(Trogoderma)* are small, about 1/8 inch or longer, and are dull dark brown or black mottled with tan markings.

Larvae:

Dermestid larvae are hairy beetle grubs from less than 1/8 to about 1/2 inch long.

- The **larder beetle** is long, about 1/2 inch, hairy, and dark brown with two teeth on the sides of the end segment pointing rearward.
- The **hide beetle** has the same characteristics as the larder beetle, except the end segment teeth are curved upward.
- The **black carpet beetle** is carrot-shaped. Its body ranges from about 1/4 inch to about 1/2 inch. The front end is widest and tapers to the rear. It is covered with dark brown to golden-red hair. It has a long, twisted tuft of hairs at the narrow tail end that may be worn down or broken off.
- The **common carpet beetle, the furniture carpet beetle, and the varied carpet beetle** are dark, short, and less than 1/4 inch long. They are wider in the middle than at the front or rear end, with dark hair bristles that extend out from the body. The tail end is darker with short brushes of bristles.
- **Warehouse and cabinet beetles** usually are small but may reach 1/4 inch. They are long, capsule-shaped, and a light cream color, with a dark row of hairs across each segment and reddish brown bristles of short hairs on the segments of the blunt tail end.

HIDE AND LARDER BEETLES *(Dermestes* spp.*)*

These beetles (from which the entire family takes its name) are larger than other dermestids, but rather than feeding on fabrics or grain, their larvae commonly eat bird and mammal flesh. They feed in remote, dark places, preferring their food dry rather than spoiled. These beetles will attack cured meats, such as ham, and they are often found infesting dead birds caught in a chimney or wall void, or mice that were caught in traps or succumbed to poison. Larvae consume all the flesh and the heavier hairs, leaving a perfectly cleaned skeleton in a small pile of fluffy undercoat hair. The **hide beetle,** in particular, is used in museums to clean vertebrate skeletons. Both beetles eat leather, but the larder beetle is found more in homes, cabins, and curing sheds.

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

Black carpet beetle adults are frequently found near the larval infestation inside buildings. In the spring, they will, on occasion, fly inside from feeding outside on flowers. Black carpet beetles also infest grain in elevators and mills. In homes and other buildings, they most commonly infest woolen fabrics. Black carpet beetles build up in stored woolen clothes such as suits, uniforms, skirts, blankets, felt, and wool yarn.

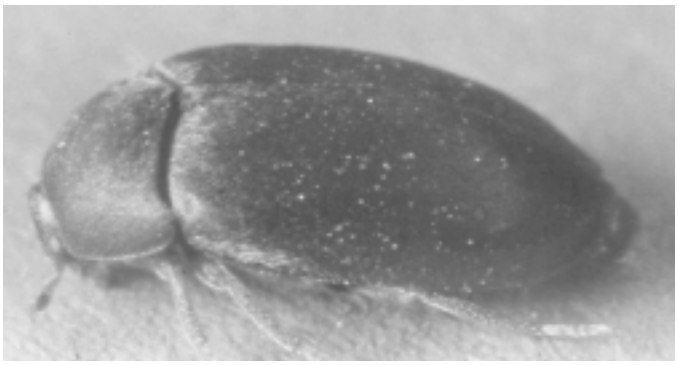


Figure 8.17. Black carpet beetle, *Attagenus* spp.

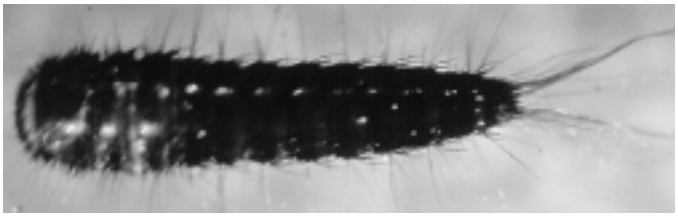


Figure 8.18. Black carpet beetle larva.

COMMON, FURNITURE, AND VARIED CARPET BEETLES (*Anthrenus* spp.)

These very small, somewhat brightly colored beetles are responsible for infesting woolens, furs, feathers, hair-stuffed antique furniture, woolen carpets, and blankets. They are also known to destroy insect collections, reducing individual specimens to piles of tiny fecal pellets.

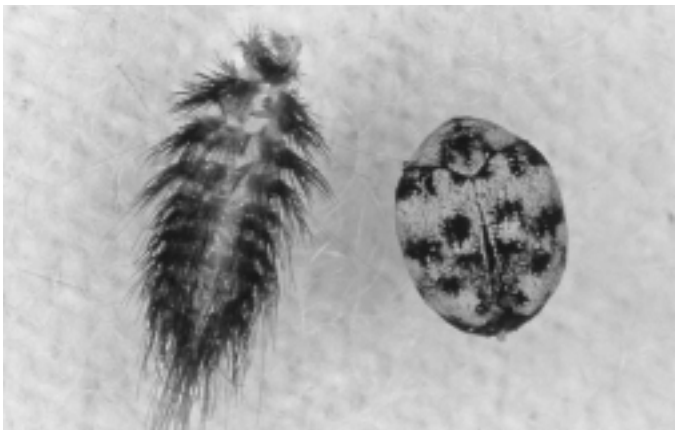


Figure 8.19. Furniture carpet beetle, *Anthrenus flavipes*, larva (left) and adult (right).

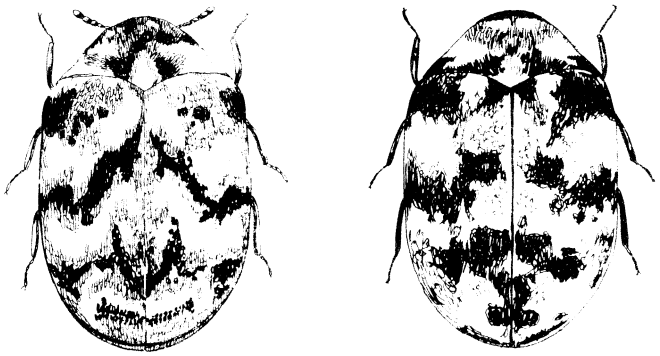


Figure 8.20. Varied carpet beetle, *Anthrenus verbasci* (left), and furniture carpet beetle, *Anthrenus flavipes* (right).

CONTROL AND MANAGEMENT OF CARPET BEETLES

Inspection

- Inspections for dermestid beetle infestations depend first on the type or kind of beetle identified.
- Look for accumulations of cast skins and large amounts of fecal pellets, as well as irregular holes and loose, patchy fur.
- Advise clients to take all woolen clothing and furs out of closets and brush them. Brushing helps to dislodge eggs and larvae; infestations are discovered in the process.
- Look in every storage box, under all furniture sitting on wool rugs and carpets. Inspect tapestries, insect collections, and grain products. Thoroughly inspect every closet, attic, and basement.
- Use pheromone traps to detect infestations early.

Habitat Alteration

- 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 for pet hair, which 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 than those that are used seasonally.
- Store all cleaned fur, feather, and woolen products in tight chests or good plastic garment bags. Furs are best kept safely in refrigerated vaults at furriers.

Pesticide Application

- Where infestations are found, spot applications of registered pesticides can be applied to storeroom or closet baseboards and corners.
- Apply pesticides in cracks and crevices of infested rooms after the infestation is eliminated.
- Use naphthalene flakes in tight chests where vapors and odor will not be breathed by occupants. 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.

Follow-up

Conduct a pest management plan emphasizing routine monitoring in high-risk areas such as museums, woolen or fur storage facilities, etc. Use pheromone traps for effective monitoring. Museum staff should reinspect annually, and pest management personnel should monitor records regularly. Emphasize educational programs for curatorial staff and storage management personnel in critical facilities.

CLOTHES MOTH SPECIES

Clothes moths fare better in warm, humid climates, so southern regions in the United States have historically produced more infestations than northern areas.

Adult moths are very secretive. They are very small and never fly to lights, choosing instead to remain in dark areas or not to fly at all. They scuttle down into dark folds of textiles or fur. Clothes moths need humidity.

- The adult **webbing clothes moth** (*Tineola bisselliella)* has a length at rest of $\frac{1}{4}$ to $\frac{1}{3}$ inch with a wing span of less than $\frac{1}{2}$ inch from tip to tip. Its head and front wings are a golden buff. **Webbing clothes moth larvae** spin fine silk over the area of their infestation. Fecal pellets, pupal cases and cast head capsules catch in the silk and create a messy accumulation. Webbing clothes moth larvae are small, creamy white caterpillars. The larva is between $\frac{1}{4}$ to less

than $^1/_2$ inch at most with a white, shiny body. It has a brown head and a brown segment behind the head. It is often found in loose silk webbing.

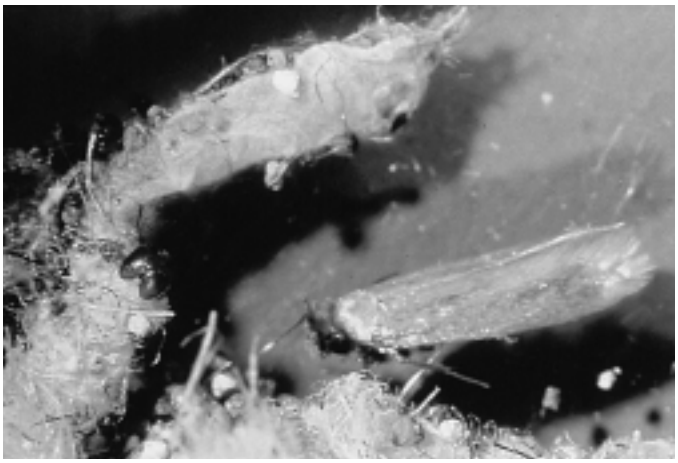


Figure 8.21. Webbing clothes moth, *Tineola bisselliella.*

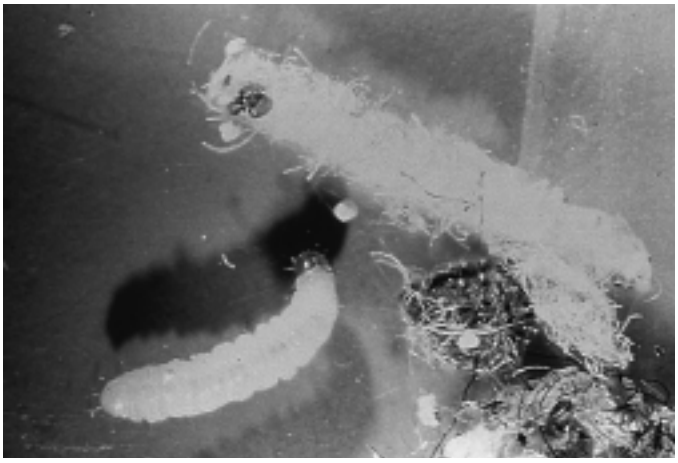


Figure 8.22. Webbing clothes moth larva and silk tube.

- The adult **case-making clothes moth** *(Tinea pellionella)* is the same size as the webbing clothes moth, but its head and front wings are dusty brown or tan with three small dark spots on each front wing. **Case-making clothes moth larvae** feed on woolen yarn but incorporate tiny strands into a silken bag or case that covers their abdomen. They crawl with three pairs of legs and hold the case with hooks on stumpy abdominal legs. The color of their cases indicates the color of the infested material. The larvae are slightly longer than larvae of webbing clothes moths. It is very light or white with a dark brown head. The segment behind its head is dark brown. The caterpillar constructs a case about its body, which it carries about when feeding. Mature larvae after leaving the infestation attach to ceilings and walls and pupate inside the case.

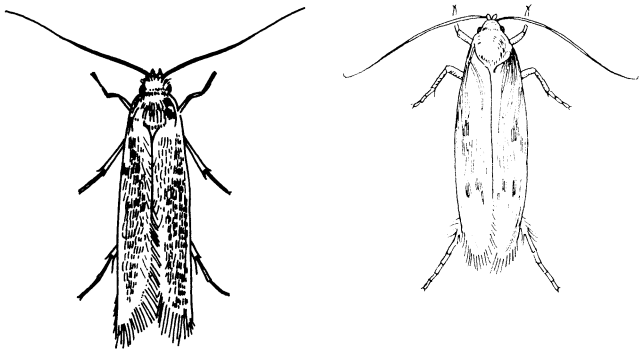


Figure 8.23. Webbing clothes moth, *Tineola bisselliella* (right), vs. case-making clothes moth, *Tinea pellionella* (left).

CONTROL AND MANAGEMENT OF CLOTHES MOTHS

Inspection

- All woolens should be inspected where clothes moths have been sighted, especially clothing that is stained or has been worn and not cleaned.
- Brush fabric to dislodge eggs.
- Look for woolen-based products introduced from Central and South America.

Habitat Alteration

Clothes moths cannot live on cleaned wool. They are very dependent upon sweat-, food- or urine-stained wool, fur, silk, and feathers. Without certain vitamins produced by microorganisms growing on the stains, clothes moth larvae will die.

- 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.

Pesticide Application

- Make spot applications in storage areas with approved pesticides.
- Apply naphthalene or paradichlorobenzene (PDB) flakes at the labeled rate to tight chests and storage bags that 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.

Follow-up

Develop a pest management program with an emphasis on monitoring for signs of insects. Closely monitor stained tapestries, clothing, furniture coverings, stuffings and other materials that are likely to become infested. Review records regularly, and provide educational programs to curatorial staff and those in textile storage businesses.

SUMMARY

Stored-product pests include a wide range of insects that feed on grain, seeds, and other plant parts that are stored, milled, or processed. Some of these pests infest stored products at every point from their origin in fields to granaries, mills, processing plants, warehouses, retail stores, food-serving establishments, and homes. Some species of stored-product pests can feed on the whole, intact grain. Most can feed only on grains that have been broken or milled, and some feed on processed herbs and spices. Each pest species has a preferred environment and group of foods. Stored-product pest infestations are not easy to discover when populations are low or building up. Pheromone traps (traps that use specific attractants) are very helpful in monitoring stored products in a pest management program. Locating and discarding infested products in homes and restaurants is a common method used in stored-product pest control.

Fabrics made of wool, furs, and feathers are attacked by a few species of beetles and moths that can consume a protein called keratin. These pests also consume grains, leather, meat, and horn, as well as dead insect skeletons. Originally, these insects were scavengers in mammal and bird nests, dead vertebrate bodies, and seeds. When humans began using these materials as food and clothing, the pests came too. Fabric pests destroy textiles, tapestries, and carpets in museums, clothing in homes, and furs in warehouses and stores. These are often both expensive and unique products. The pests do not thrive in cleaned textiles and wool because they need certain vitamins produced by fungi found along with stains of perspiration, urine, and human food; added to this is a requirement for moisture

SECTION 2 CHAPTER 8

Review Questions

Chapter 8: Stored-Product and Fabric Pests

Write the answers to the following questions and then check your answers with those in Appendix A in the back of this manual.

1. Some common stored-product pests that attack whole grains and chew through the seed coat are:
   A. Rice and granary weevils.
   B. Red and confused flour beetles.
   C. Psocids and grain mites.
   D Saw-toothed and merchant grain beetles.

2. Pheromones are used in:
   A. Sprays.
   B. Traps.
   C. Dusts.
   D. Warehouses.

3. ____ is not commonly a food of stored-product pests.
   A. Dried fruit
   B. Paprika
   C. Paper products
   D. Cornmeal
   E. Mung beans

4. The primary method of reducing stored-product pest populations is:
   A. Sanitation.
   B. Pesticide use.
   C. Caulking.
   D. Ventilation.

5. When using pesticides to control stored-product pests:
   A. Use crack and crevice in infested areas.
   B. Use of aerosols is common.
   C. Use a general insecticide application.
   D. Use pheromone traps in conjunction with other methods.
   E. A & D

6-9. Match the following to the appropriate description.

A. Rice and granary weevils
B. Angoumois grain moth
C. Lesser grain borer
D. Seed beetles or pea and bean weevils

_____ 6. Most commonly found in whole corn.

_____ 7. Mainly a problem of stored grain in transport.

_____ 8. Infests only seeds of legumes.

_____ 9. Have long snouts with jaws (mandibles).

10. Cockroach bait stations with a grain base can be used to control:

A. Indian meal moth.
B. Flour beetles.
C. Saw-toothed grain beetles.
D. Cigarette beetles.
E. A & B

11-17. Match the following to the appropriate description.

A. Indian meal moth
B. Saw-toothed grain beetle
C. Cabinet or warehouse beetle
D. Cigarette and drugstore beetles
E. Flour beetles
F. Spider beetles

_____11. About 1/8 inch long, three ridges on top of thorax with six fine teeth on either side.

_____12. Especially like paprika.

_____13. In the same family as carpet, hide, and larder beetles.

_____14. Beetle about 1/8 inch long, reddish brown; larvae longer than adults.

_____15. Monitor with sticky traps.

_____16. Beetle less than 1/8 inch long, oval; larvae tiny, white and curved.

_____17. Larvae cover the top of a product with silk.

18. Psocids and grain mites need _____ to build large populations.

A. Grains
B. Processed meal
C. High-protein grain
D. High humidity

19. While inspecting a mill, you find beetles with long snouts and dark forewings that cannot fly. You suspect the mill is infested with:

A. Rice weevils.
B. Cigarette beetles.
C. Drug store beetles.
D. Granary weevils.
E. Saw-toothed beetles.

20. What would be the recommended control method for the situation in Question 19?

A. Discard infested materials.
B. Recommend rotating stock.
C. Point out areas that need ventilation.
D. Recommend reduction of clutter.
E. All of the above.

21. A homeowner complains that his dog's food is infested. On closer inspection, you find oval beetles (greater than 1/8 inch) that are black with reddish brown gray lines across the body. Most likely the dog food is infested with:

A. Saw-toothed beetles.
B. Spider beetles.
C. Cigarette beetles.
D. Cabinet beetles.
E. Lesser grain borer.

22. The principal need of fabric pests seems to be:

A. Wool.
B. Carbohydrates.
C. Protein.
D. Starches.

23. Two groups of insects feed on stored woolens, furs, feathers. They are:

A. Clothes moths and carpet beetles.
B. Carpet moths and blanket beetles.
C. Blanket beetles and warehouse beetles.
D. Clothes moths and tapestry moths.

24. **Adult** carpet beetles are responsible for most textile damage.
    A. True
    B. False

25-29. Match the following to the appropriate description.

    A. Larder beetles
    B. Hide beetles
    C. Black carpet beetles
    D. Common carpet beetles

    _____ 25. Adult is mottled (< 1/8 inch long), covered with small flat scales; larvae have dark hair bristles.

    _____ 26. Larvae carrot-shaped; covered with dark brown to golden red hair.

    _____ 27. Large beetles 1/4 to 3/8 inch long; larvae; white scales underneath.

    _____ 28. Large beetles 1/4 to 3/8 inch long; wings half dull yellow, half black.

    _____ 29. Infests grain in mills as well as woolen fabrics.

30. The larvae of hide and larder beetles prefer to feed on bird and mammal flesh rather than fabrics or grain.
    A. True
    B. False

31. The black carpet beetle does not normally feed on:
    A. Wool.
    B. Grain.
    C. Fur.
    D. Leather.

32. Fabric pests are found infesting a home. Advise the homeowner to:
    A. Clean up pet hair.
    B. Keep all woolen clothing in long-term storage.
    C. Dry-clean infested clothing.
    D. B & C
    E. A & C

33. While inspecting a closet, you find clothing covered with a fine silk. The silk contains fecal material and pupal cases. You suspect the client has a problem with:
    A. Indian meal moths.
    B. Spider beetles.
    C. Case-making clothes moths.
    D. Angoumois grain moths.
    E. Webbing clothes moths.

34. When using pesticides to control fabric pests:
    A. Use naphthalene in open areas.
    B. Use naphthalene over PDB.
    C. Use PDB over naphthalene.
    D. Apply crack and crevice pesticide when infestation is first noticed.

35. The most important element in a pest management program for fabric pests in a museum would be:
    A. Fogging.
    B. Monitoring.
    C. Dusting.
    D. Spraying.

36. The "case" of the case-making clothes moth:
    A. Covers their abdomen.
    B. Is carried by adult moths.
    C. Indicates what material is infested.
    D. A & C
    E. All of the above

37. Clothes moths depend on _____ more than carpet beetles.
    A. Vitamins from stained clothing
    B. Woolens and furs
    C. Proteins and starches
    D. Bird and mammal flesh
    E. Insect bodies

38. For which type of insect pest is monitoring with pheromone traps recommended?
    A. Rice and granary weevils
    B. Indian meal moth
    C. Carpet beetles
    D. Cabinet or warehouse beetles
    E. All of the above

39. Which type of insect pest's nutritive requirements are met by fungal infested cereal products?
    A. Case-making clothes moth
    B. Indian meal moth
    C. Grain mites
    D. Rice and granary weevil
    E. Black carpet beetle

SECTION 2
CHAPTER 9

SILVERFISH AND FIREBRATS

LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Be able to identify the various silverfish/firebrat species on the basis of 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.

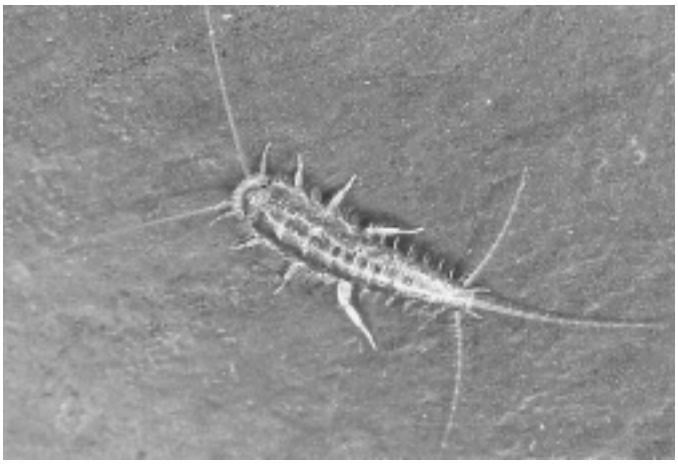


Figure 9.1. Silverfish.

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.

The silverfish and the firebrat are the most common representatives of the "bristletails." Pest bristletails are about ½ inch long when adult and, unlike other insects, they continue to molt and may shed their exoskeletons as many as 50 or 60 times when full grown. They have long antennae in front and three antenna-like processes on the abdomen (the "bristles" of the bristletails). They are slender, broadest in front and gradually tapering toward the rear. In general, they shun light and prefer dark, undisturbed sites.

COMMON SILVERFISH *(Lepisma saccharina)*

The silverfish is about ½ inch long when full grown and is covered by a sheen of silvery scales. It prefers temperatures between 70 and 80 degrees 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, but they can also digest cellulose fibers.

Silverfish build up around the materials they are feeding 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 as a result of the humidity and insect fecal deposits.

Figure 9.2. Silverfish damage.

[Figure 9.3. Firebrat, *Thermobia domestica.*

Large populations of silverfish spread out into other humid areas. Silverfish are often trapped in wash basins and bathtubs in bathrooms to which they migrate from the basement or out of wall voids penetrated by pipes.

GRAY SILVERFISH (*Ctenolepisma longicaudata)*

The gray silverfish is uniformly gray, sometimes very dark. This species occurs indoors in the South, the Midwest, and southern California. It prefers drier areas than the common silverfish, such as crawl spaces and attics, but may occur around water pipes in bathrooms. This species is more a pest of paper and textiles.

FOUR-LINED SILVERFISH *(C. quadriseriata)*

The four-lined silverfish has four dark lines down its abdomen and is very slightly longer than the common silverfish. It builds up in the mulch of flowerbeds and under roof shingles, then enters attics and upstairs rooms. This species is common on the East Coast and West Coast and the Midwest. High humidity from overhanging trees in summer promotes buildup of this species. It often lives indoors and infests attics, particularly if the roof is made of wooden shingles. It may be found outdoors in summer. Its life cycle is similar to that of the common silverfish but is not as limited by temperature and moisture.

FIREBRATS *(Thermobia domestica)*

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

CONTROL AND MANAGEMENT OF SILVERFISH AND FIREBRATS

Inspection

- Place silverfish and firebrats in alcohol to preserve them. They are soft and very fragile. When they are captured for identification, scales are usually rubbed off and appendages broken off.
- Check all starch-based materials in the infestation area, including glued boxes, wallpaper, books and book bindings, art prints, file boxes, kitchen and bathroom cupboards, glued insulation batts, flour paste, and stored textiles, especially those that are starched or sized.
- Inspect rooms connected to infested areas through wall or floor penetrations, or through closet ceilings.
- Note areas with high humidity and high temperatures.

Habitat Alterations

- Locate moisture sources.
- Mend pipe leaks.
- Ventilate closed rooms, attics, and crawl spaces.
- Dehumidify humid spaces.
- Eliminate standing water.
- Make changes in grade and guttering where water runoff causes damp basements and walls.
- Eliminate stored materials that harbor bristletails.
- Dispose of infested storage boxes and relocate stored materials in dry spaces after inspection of materials.
- Trim trees where shade is causing moist conditions on roofs and roof eaves.

Pesticide Application

- Use crack and crevice applications of 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.
- Treat attics where four-lined silverfish are found.

Follow-up

Educate the client regarding the bristletail's need for starch-based foods and humid conditions, and the firebrat's attraction to areas with high temperatures.

SUMMARY

Ancestors of silverfish and firebrats are among the most ancient insects. Silverfish prefer a moist or humid environment with a moderate temperature. Several species of silverfish live outside and inside. Firebrats, on the other hand, seek very hot places such as bakeries, furnace rooms, and hot apartment bathrooms.

Both silverfish and firebrats feed on starchy materials such as flour, paste, glue, and textiles and paper sized with starch. They prefer boxes of books, corrugated cardboard, flour or cake mix spills, glued insulation batts, taped heat pipes, etc. They also eat paper.

Removing the infested material is the first step in control of these pests. Ventilating moist or hot spaces and using pesticides will quickly suppress these pests

SECTION 2 CHAPTER 9

Review Questions

Chapter 9: Silverfish and Firebrats

Write the answers to the following questions and then check your answers with those in Appendix A in the back of this manual.

1. The common silverfish prefers moderate heat and high humidity.
   A. True
   B. False

2. The most common silverfish outside is the:
   A. Common silverfish.
   B. Firebrat.
   C. Four-lined silverfish.
   D. Gray silverfish.

3. The firebrat prefers moderate heat and high humidity.
   A. True
   B. False

4. Silverfish and firebrats prefer to consume:
   A. Carbohydrates.
   B. Starches.
   C. Proteins.
   D. Vitamins.

5. Trimming overhanging trees is a control recommendation for:
   A. Common silverfish.
   B. Gray silverfish.
   C. Four-lined silverfish.
   D. Firebrats.

5-11. Match the following to the appropriate description.

   A. Silverfish
   B. Firebrat
   C. Both
   D. Neither

   _____ 6. Most likely to be found in a furnace room.
   _____ 7. Molt 50 to 60 times as adults.
   _____ 8. Can fly as adults.
   _____ 9. Prefer dark, moist areas.
   _____10. Mottled dark gray and dull yellow.
   _____11. Have "bristletails."

12. Which is a sign of silverfish feeding?
    A. Irregular holes in houseplants
    B. Irregular, yellow-stained holes in paper
    C. Areas grazed off of cloth-bound books
    D. Infested grain and cereal products
    E. B & C

13. List some habitat alterations for controlling silverfish and firebrats.

14. List some pesticide applications for controlling silverfish and firebrats.

SECTION 2

CHAPTER 10

FLEAS

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 alterations and why they are needed.
- Be able to identify pesticide application methods for flea control.
- Understand when, how, and why insect growth regulators (IGRs) are helpful.

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 fleas are common in all parts of the country except very dry areas.

The most important species that pest control technicians must manage is the **cat flea,** which feeds on a variety of hosts, including cats, dogs, 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 not uncommon for families to remove their pets while on vacation and then return home to find ravenous fleas.

An outline of the sequence of events:

- A summertime vacation assures good flea-growing conditions (temperature and humidity).
- Taking the pet removes the main host.
- While the family is away, larvae continue to develop, feeding on dried blood. Pupae complete their cycle and are ready to emerge.
- The family returns to the newly emerged adult fleas—ready to feed and accept ALL available warm-blooded hosts.

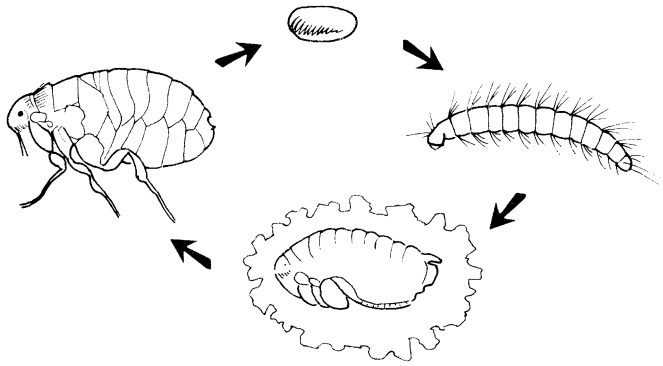


Figure 10.1. Fleas undergo complete metamorphosis through egg, larval, pupal, and adult stages.

CAT FLEA *(Ctenocephalides felis)*

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 pet bedding, furniture, carpets, etc., they shake down to the same level as the pepper-like dried blood (see larvae and adults). These eggs will hatch in one week to ten days.

Figure 10.2. Cat flea—egg, larvae, adult, and feces.

Larvae

Larvae are tiny, worm-like, whitish (almost transparent) insects with small brown heads. When larval fleas hatch, they are only $^{1}/_{6}$ inch long. After three molts, they grow to near $^{1}/_{4}$ 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, pet bedding, etc.) moving by using a pair of spines at their rear and long (but nearly invisible) hairs on each segment. Larval fleas are scavengers and do not suck the host's blood or live on hosts. Cat flea larvae have chewing mouthparts that they use to eat specks of dried blood (see adults). 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 developed 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 gets covered with dirt particles and other detritus during its construction.

Figure 10.3. Cat flea larva.

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" until stimulated to leave the cocoon. This pupal stage is completed within seven to ten days, but 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.

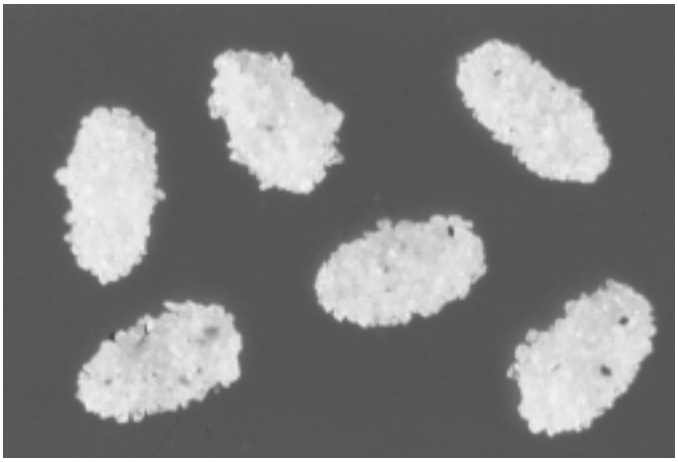


Figure 10.4. When immature fleas complete the larval stage, they pupate inside silken cocoons.

Adults

Adult fleas live on the pet and in the pet's sleeping or resting area. Adult fleas are parasites—they obtain their nourishment from a host animal, usually a mammal. They feed by biting and sucking blood, sometimes daily, for two or three weeks. 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

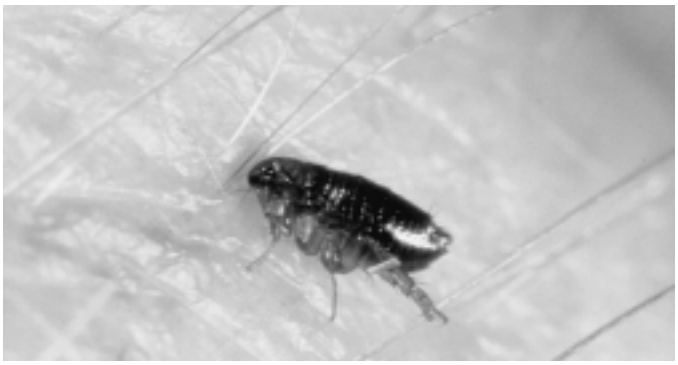


Figure 10.5. Only adult fleas feed on blood. A blood meal from a warm-blooded animal is necessary for females to produce eggs.

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 fleas are not evenly distributed throughout a home or building. The larvae use this dried blood as a food source.

Fleabite and Flea Allergy

The fleabite is accompanied by secretions of saliva that prevent the host's blood from coagulating. The saliva contains several chemicals that cause irritant reactions, sometimes including hypersensitivity to subsequent fleabites. 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 allergy also seems to be hereditary.

Range

In the past, flea control in the northern United States consisted of a summer spray inside and treatment of the pet because reinfestations from outside were not common. In the southern states where outside infestations were common, treatment in the yard was also needed. Today flea infestations and reinfestations are common in all parts of the country except very dry areas.

CONTROL AND MANAGEMENT OF FLEAS

Inspection

Indoor. A close inspection of a home or building 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 building. 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., immediately 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.

Outdoor. Kennels and doghouses are obvious places where fleas build up. But 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 infestations 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 undrained 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, in fact, have overpopulated some urban areas. They live in chimneys, large trees and storm sewers. Chipmunks, ground squirrels, and domestic rodents have also found habitat in ivy terraces, rock walls, soil berms, and underground drainage areas. The opossum has extended its range or has been introduced over most of the United States. It is one of the most common urban wildlife species found today.

Pets are always aware of the locations of wildlife habitat in their own backyard. As soon as they are released, they run to these places to investigate, even if they can't get at the animals. This behavior ideally facilitates flea reinfestation of clean pets.

Habitat Alteration

Indoor. Flea populations build up in the warm, humid weather of spring and summer and drop to low levels in cool or dry winter weather. Inside air with low humidity will hold back the buildup of flea populations.

When focus areas of flea populations are identified, these and other potential harborage sites should be vacuumed as thoroughly as possible. Except for flea allergy dermatitis, which can be initiated with very few fleabites, a moderate flea population can be kept at a tolerable level by vacuuming alone. This vacuuming MUST be performed daily and must always be thorough—an alternative very few pet owners would choose when other safe and effective options are available. If vacuuming is augmented by use of growth regulators, better success can be predicted.

Reduction of clutter facilitates inspection and permits effective pesticide application and vacuuming. Pets and feral animals should be kept out of crawl spaces, areas under porches, and outbuildings. Eliminating the wildlife habitat where fleas are harbored, and trapping or killing animals responsible for reinfestations may become essential in stopping difficult flea infestations. Care should be taken, however, not to rely on wild animal elimination alone. These animals are usually replaced by others moving in from adjacent range (see outside treatment). Consult local restrictions when dealing with wild mammals.

Pesticide Application

Treatment of Pets. Pets should be treated by the pet owner or a veterinarian. Where flea allergy dermatitis is involved, pets must be treated by veterinarians 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 powders and sprays and they should be used according to label information. "Dipping" pets is done most effectively by veterinarians. Flea collars may help with some flea infestations, but they are generally the least effective treatment.

Treatment of puppies and kittens with dusts 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. 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 come in contact with 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 able to "dodge" treatments and expose themselves 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 overwetting 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, but they will come into contact with the pesticide residue when they move up or out of the nap. Some fumigant 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, where flea allergy dermatitis must be avoided, where animals are in poor health, and where outside infestations 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 even begin to be noticed (depending on the local climate). 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 or 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 openings into basements and attics where pets or wild animals nest should not be closed off until the animals are removed and the area 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.

Where they can be applied, dusts are often more effective. Take care not to overapply dusts. Dusting burrows or the protected nesting areas of wild animals can be very effective and might eliminate the need for trapping or killing these animals.

Pesticides should be reapplied when rainy weather follows pesticide application.

Ultrasonic devices. Clients have been led to believe that ultrasonic devices are effective flea deterrents. Cat fleas have NOT been shown to react to a broad spectrum of ultrasound; consequently, there is no utility for ultrasonic devices in a flea-management program.

Follow-up

Thorough client education is essential both before and after flea management programs are conducted. Clients must be well informed or they will not be motivated to carry through with the steps they alone can do. Flea infestations often bring about emotionally charged situations—especially when anxieties prevail, such as when children are involved or the infestation is long term.

Pest management technicians must be able to clearly and patiently explain the flea life cycle and how each stage is important. They must clarify how infestations can persist and that there may be no easy or quick solution. Where infestations are severe or where management procedures may not be completely carried out, a reinspection and possible retreatment should be scheduled before a rebounding population cancels out all of the previous work and cooperative effort.

SUMMARY

Fleas are mainly parasites of mammals and birds. They undergo a complete metamorphosis. The eggs drop off of the host where the female deposits them during feeding periods. Larvae with chewing mouthparts hatch and feed on dried host blood provided by the feeding female flea. Prior to pupating, the larva spins a small, loose, white, silk cocoon. The pupa molts to an adult inside the cocoon. Adults emerge from the pupal cocoon, find the host, feed by sucking blood, mate, and produce eggs. The cat flea is the most common flea infesting dogs and cats in the United States.

Understanding the life cycle of the flea, the dependence of this pest on its host, and the importance of the dried host blood is essential to flea control. Removing dried blood and adult fleas by vacuuming, killing the adult fleas, and using an insect growth regulator to keep the larvae from pupating will control most flea populations.

SECTION 2
CHAPTER 10

Review Questions

Chapter 10: Fleas

Write the answers to the following questions and then check your answers with those in Appendix A in the back of this manual.

1. The food of flea larvae is principally:
   A. Blood they suck from the host.
   B. Dried blood from the female flea.
   C. Fur from the host.
   D. Starch.

2. Adult fleas obtain blood by:
   A. Sucking.
   B. Chewing.
   C. Absorbing.
   D. Lapping.

3. Pupal "pre-adult" fleas may remain in a cocoon for months.
   A. True
   B. False

4. The pepper-like specks observed falling from a pet after scratching are:
   A. Adult fleas.
   B. Larval fleas.
   C. Fecal blood.
   D. Cast skins.

5. Flea larvae:
   A. Need moisture.
   B. Need free-standing water.
   C. Crawl away into cracks, carpets, etc.
   D. Attach themselves to hosts.
   E. A & C

6. Pets that are flea hosts sleep and loaf in particular places rather than randomly lying down when they are tired.
   A. True
   B. False

7. Dogs can become allergic to fleabites.
   A. True
   B. False

8. For control of fleas, it is NOT important for the pet owner to:
   A. Remove the pet.
   B. Vacuum pet resting spots.
   C. Treat the pet.
   D. Clean pet bedding.

9. A homeowner complains that a family pet is constantly scratching and is losing patches of hair, and its skin appears to be red and inflamed. You should:
   A. Advise homeowner to treat the pet with over-the-counter powders/sprays.
   B. Advise homeowner to have veterinarian treat pet.
   C. Treat the pet yourself with powders/sprays.
   D. Advise homeowner to place flea collar on pet.
   E. Dust and spray the pet's bed and kennel.

10. Which non-toxic alternative (habitat alteration) is the MOST effective at controlling fleas?
    A. Thorough vacuuming
    B. Reducing vegetative cover around home
    C. Reducing clutter
    D. Decreasing household temperature

11. Application of an IGR will:
    A. Kill adults.
    B. Immunize the pet.
    C. Keep larvae from developing into pupae.
    D. Keep eggs from hatching.

12. IGRs:
    A. Should be used one month before flea activity is usually noticed.
    B. Can be used in combination with ultrasonic devices.
    C. Are effective at retarding the growth of adult fleas.
    D. Can be used in combination with spot treatments.
    E. A & D

13. Thorough vacuuming along with use of IGRs will control most flea populations.
    A. True
    B. False

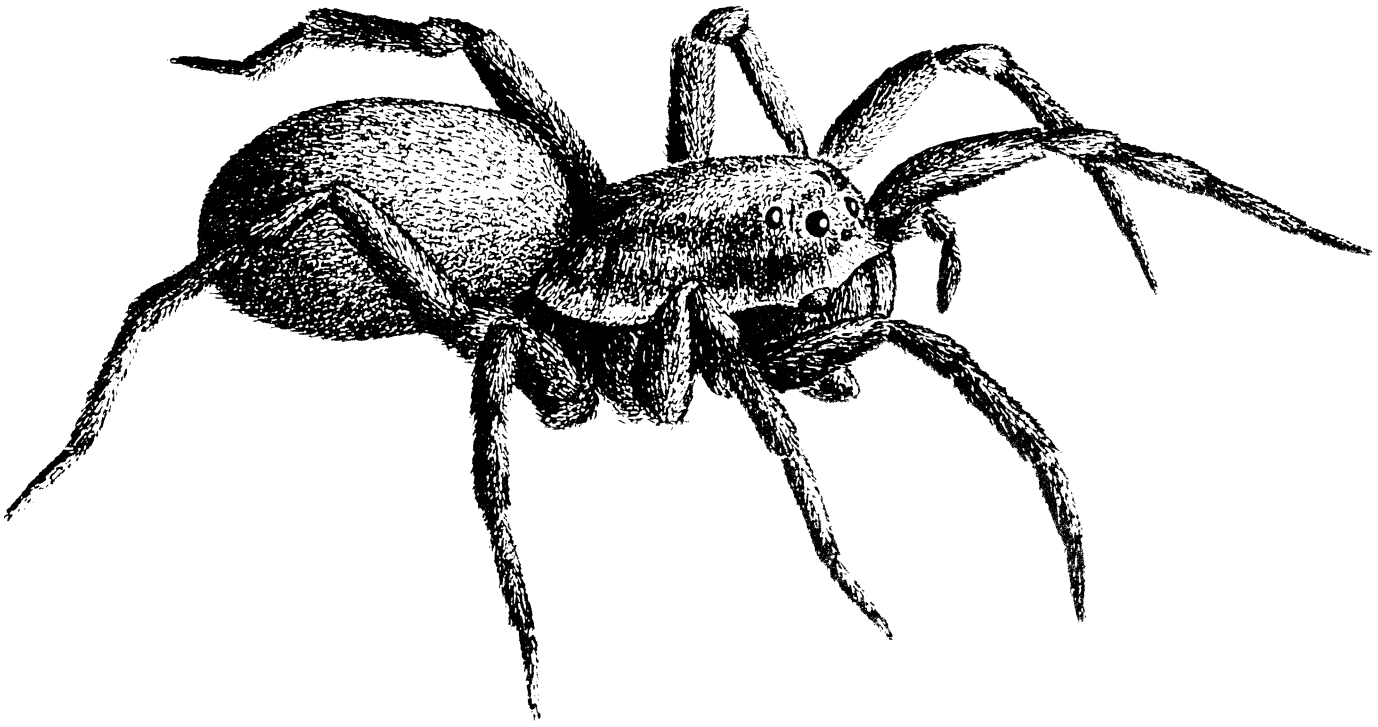
SECTION 3

INVADING PESTS

This section covers arthropod species that primarily live outside. These individuals are from the local fauna and invade human habitat but do not reproduce inside. Exceptions to this are spiders, honeybees that inhabit building wall voids, and human lice, whose unique habitat is difficult to designate as outside or inside. A final group—the imaginary pests—are neither outside or inside.

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 technicians are certain to find these pests interesting and their management challenging.



SECTION 3

CHAPTER 11

HOUSEFLIES AND THEIR RELATIVES

LEARNING OBJECTIVES

After completely studying this chapter, you should be able to:

- 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 four: 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 orders 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 the head.

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

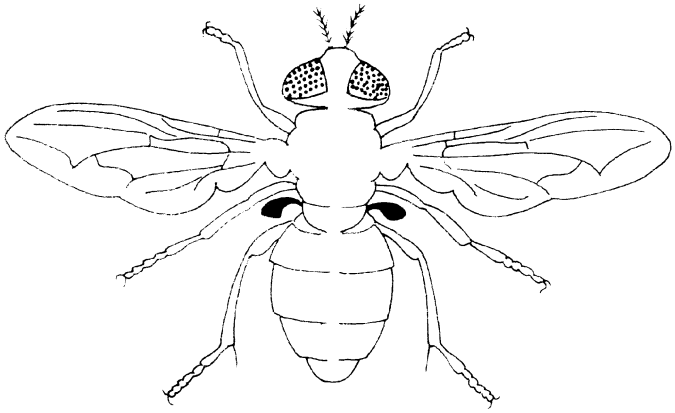


Figure 11.1. Flies and all other dipterans have one pair of wings while all other winged insects have two pairs. In place of the second pair, flies have knobbed balance organs called halteres (illustrated in black).

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.

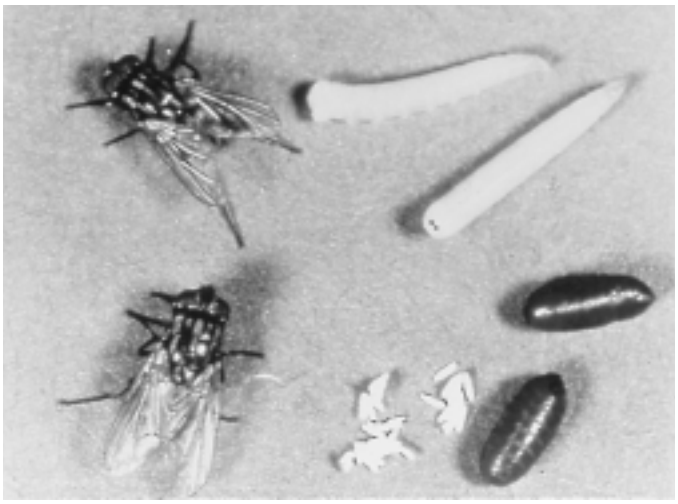


Figure 11.2. Housefly—eggs, larvae (maggots), and pupae.

Flies often tell the same story; they frequent garbage, dead animals and manure. Their larvae live in that material. To enter a house, they have flown inside through an open door or window, or they have moved from a dead animal in a wall.

LARGE FLIES

HOUSEFLIES, BLOWFLIES, AND OTHERS

Appearance

Both the **housefly** *(Musca domestica)*, which lives on garbage or manure, and its close relative, the **face fly** *(Musca autumnalis)*, which lives on fresh cattle manure, are about 1/4 inch long. They have a dull gray thorax with dark stripes and a dark, dull abdomen with yellow sides.

Figure 11.3. Housefly *(musca domestica).*

Flesh flies (the family Sarcophagidae) live on meat scraps, dead animals, and dog excrement. They are more than 1/4 inch long, have a dull gray thorax with three distinct dark stripes, and a gray checkerboard abdomen.

Figure 11.4. Flesh fly, family Sarcophagidae.

Blowflies (the family Calliphoridae) are about 1/4 inch long. Their thorax and abdomen are shiny black, metallic green or bronze, or they have a metallic blue abdomen with a dull thorax. They live on dead animals, meat scraps in garbage, and wet-mixed garbage.

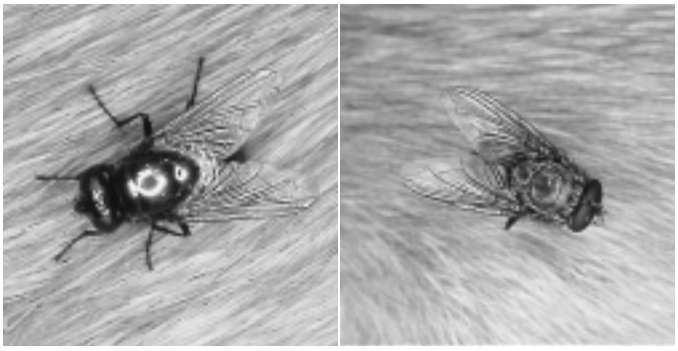


Figure 11.5. Blowflies: greenbottle fly, *Phaenicia sericata* (left), and bluebottle fly, *Calliphora vicina* (right).

The cluster fly *(Pollenia rudis)* is also in the family Calliphoridae. It is slightly more than 1/4 inch long. Its thorax is covered with gray or yellowish hairs; it has no stripes. Its abdomen is dark gray with light patches.

In favorable weather, housefly larvae mature in 6 to 10 days and blowflies in 3 to 9 days. They live in refuse only from the egg-laying to the mature larval stage. Then the mature larvae crawl away to pupate, emerging as adults later.

CONTROL AND MANAGEMENT OF LARGE FLIES

Inspection

When any of these flies become problems inside, their breeding site and their larvae will usually be close by. If animals are nearby, investigate for manure concentrations. Garbage cans and dumpsters are often the problem source; even soil where garbage has decomposed will support infestations.

- Houseflies infest most garbage, manure (horses, cattle, poultry, pet), and filth accumulations.

- Face flies need fresh cattle manure for egg laying.
- Flesh flies, like blowflies, live in pet manure, meat scraps in garbage, and dead animals.
- Blowflies are scavengers and live in manure, carrion, dead birds, and dead rodents in wall voids and chimneys. One blowfly, called the cluster fly, parasitizes earthworms.
- Look for fly sources where buildings are infested. Observe sanitation in the areas where flies are problems.
- The most common means of fly entry is through open doors. Look for door props and hooks, as well as gaps where broom handles are stuck over hinges to hold the door open or for doors that do not fit tightly.
- Evaluate garbage management. Garbage left in the building or on loading docks is an attractant. Garbage should be removed from the premises ***twice*** a week.

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 materials 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.

Pesticide Application

- Fly strips can be placed in low-access rooms, such as attics and storerooms.
- Fly bait can eliminate adult flies when methods are in place that reduce breeding sites.
- Aerosol contact sprays can be used to knock down adult flies after elimination of breeding sites and exclusion methods are in effect.
- Ultra-low dosage applications 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 blacklight flytraps where they will attract insects from outside. Do not put them in competition with other lights, such as those from vending machines, etc.

Follow-up

Regularly check sanitation and exclusion methods to see that they are being maintained. Observe client and worker habits that run counter to the pest management program (sanitation, habitat alteration, and so forth). Hold training clinics for workers about fly management.

ATTIC FLIES, CLUSTER FLIES

Cluster flies—along with houseflies, face flies, some blowflies, and flesh flies—normally overwinter as adults. In nature, overwintering locations are under bark, in hollow parts of trees, or under the bark of logs. They begin seeking shelter at the end of the hot part of summer. If they begin investigating structure walls in their search for winter harborage, their upward movement often brings them to openings under siding, ventilators, and weep holes in masonry, cracks around windows, wire penetrations, wall voids, and openings around the roof. Unused attics are good overwintering sites.

Flies hidden in attic cracks will begin flying to windows on warm winter days. They often make their way down through closets and chimney cracks into living spaces of the house. This same behavior takes place in office buildings, hospitals, and other structures.

Control and Management of Attic Flies, Cluster Flies

Inspection

Frequently finding flies dead at windows may indicate an attic fly infestation.

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 AND PHORID FLIES

Drosophila and the Family Phoridae

These small flies (from two different fly families) often are mistaken for each other. They are about 1/8 inch long and somewhat similar looking, but their biology and management are very different. Treatments of these fly infestations are a good example of the site-specific nature of successful pest management.

Figure 11.6. Fruit flies are small flies about 1/8 inch long.

FRUIT FLIES

Several species of *Drosophila* have been immensely beneficial to mankind because of their use in the study of genetics and heredity. Fruit flies are attracted to nearly any material that is fermented by yeast. These small flies commonly have bright red eyes, although some species' eyes are dull dark red. The head and thorax are yellowish to brown, and the abdomen is light brown to dark with yellow bands.

The wing vein structure is important and can be seen with a hand lens. It consists of a thickened vein bordering the front margin of the wing from the attachment at the thorax to the wing tip. Four other long veins can be seen on the rest of the wing.

In a common fruit fly infestation, flies are attracted to the sweet odor of fermentation in ripe fruit, such as bananas; they lay their eggs in the cracks of the peel. Fruit fly larvae hatch, then feed on yeast cells in the fruit. The life cycle can be completed in not much more than a week.

Newly emerged adults are attracted to lights, but egg-laying females will not leave fermenting materials. Fruits, vegetables, beer, fermenting water from refrigerators, humidifiers, sink drains, sour mops and rags, and fermenting pet food are examples of fermenting material. Infestations are common in orchards, breweries, restaurants, canneries, hospitals, and homes.

Figure 11.7. Fruit fly, *Drosophila* spp.

Control and Management of Fruit Flies

Inspection

When certain the infesting insect is a fruit fly, look for fermenting materials. Begin with ripe fruit and vegetables, then proceed to less obvious possibilities.

- Use flytraps baited with bananas to find the most heavily infested areas when the source is very obscure.
- Be sure to inspect the outside of the building near windows.

Habitat Alteration

- Close up gaps where flies can enter.
- Use small-mesh screening to exclude these small flies.
- Discard or clean infested material.
- Use precautions to remove flies before fruit is brought to terminal points when the infestation originates in the field or orchard. Infestations in canneries and fruit markets are particularly difficult to manage.

PHORID FLIES

Phorids or humpbacked flies are about the same size as fruit flies or a little smaller. They are dark brown and look humpbacked—because the small head is located low on the front bulge of the thorax.

Wing venation consists of several short, thickened veins on the fore margin of the wing near the attachment to the thorax. These veins do not extend to the wing tip, and other veins are weak or nearly invisible. Phorids run in short jerks.

These flies become problems when they infest decomposing plant or animal matter. Buried animals, garbage, or broken sewer lines support large numbers of phorids. Phorids also infest bodies in mausoleums.

Adults are able to emerge from the underground infestation site upward through several feet of soil. If broken

sewer lines are under buildings, phorids can come up through cracks in concrete floors or around floor drains. When water and sewage wash out cavities in the soil around the pipe, immense numbers of flies are produced.

Figure 11.8. Humpbacked or phorid fly, family Phoridae.

Control and Management of Phorid Flies

Inspection

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.

Habitat Alteration

- 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.

MOTH FLIES OR DRAIN FLIES

The Family Psychodidae

Moth flies are about $^{1}/_{8}$ inch long. Their dark color comes from tiny hairs that cover the wings, which are held in roof-like fashion over the body. Moth flies have long, drooping antennae.

Larvae live in the gelatinous material in sink drain traps and sewers. Where sinks regularly overflow, these flies build up in the overflow pipe. When drain traps of sinks, commodes, and floor drains dry out, large numbers can enter dwellings from the sewer.

Drain traps should be cleaned mechanically or with drain cleaners. Without larval control, adults will constantly emerge.

In sewage treatment plants, drain flies feed on the gelatinous material that collects on stones in trickling filter beds. Over time, however, cast skins from these filter flies can slow down water drainage. When sewage treatment plant filter beds malfunction or become "out of balance," the moth flies can become problems in nearby neighborhoods. The filter bed should be cleaned by reverse- or back-flushing.

Figure 11.9. Moth fly or drain fly, family Psychodidae.

FUNGUS GNATS

The Families Mycetophilidae and Sciaridae

Fungus gnats are slender, delicate, mosquito-like insects. Their larvae infest moist soil and feed on fungi associated with decaying vegetation. Indoors, fungus gnats infest flowerpots. They also build up in pigeon droppings on outside ledges, then enter dwellings through nearby windows.

Figure 11.10. Dark-winged fungus gnat, family Sciaridae.

MIDGES

The Family Chironomidae

Midges look very much like mosquitoes but do not bite. Midge larvae live in water, especially in quiet, still water.

Adult midges are often a food source for spiders on buildings and monuments (see Web-weaving Spiders, Chapter 13). The adults fly to lights and enter dwellings through gaps.

Management is site-specific; pesticides are generally not useful. Manipulating lights to shine away from buildings will reduce midge attraction. As part of the pest management plan, note flight periods and times. The larvae of some species of midges indicate a larger pollution problem.

SUMMARY

Flies, insects with complete metamorphosis in the order Diptera, are characterized by having only one pair of wings. These insects are responsible for millions of deaths each year because of their disease-vectoring ability, particularly in less-developed countries. In urban areas, flies contaminate food and people in restaurants, hospitals, and homes. They are annoying indicators of sanitation, structural, and cultural problems.

SECTION 3 CHAPTER 11

Review Questions

Chapter 11: Houseflies and Their Relatives

Write the answers to the following questions and then check your answers with those in Appendix A in the back of this manual.

1. Briefly describe the two major divisions of the order Diptera characterized by form and give an example for each.

2-13. Match the following to the appropriate description.

A. Fruit fly *(Drosophila)*

B. Phorid fly

C. Both

_____ 2. Small in size.

_____ 3. Look humpbacked (small head).

_____ 4. Often have red eyes.

_____ 5. Attracted to yeast-producing materials.

_____ 6. Can infest buried refuse and emerge in buildings.

_____ 7. Visible vein and cross veins on wings.

_____ 8. Run in short jerks.

_____ 9. Veins do not extend to wing tip.

_____ 10. Trap with banana-baited material.

_____ 11. Most likely infesting a brewery.

_____ 12. Remove sewage-contaminated soil to control.

_____ 13. Infest manure.

14-21. Match the following to the appropriate description.

A. Houseflies

B. Face flies

C. Flesh flies

D. Blowflies

E. Cluster flies

F. All of the above

_____ 14. Resemble face flies—dull gray thorax, dull abdomen with yellow sides.

_____ 15. Solid metallic green, bronze, blue, or black.

_____ 16. Yellow or gray hairs cover thorax.

_____ 17. Gray thorax with three distinct stripes.

_____ 18. Larvae parasitize earthworms.

_____ 19. Most commonly enter through doors.

_____ 20. Attracted to garbage.

_____ 21. Need fresh cattle manure for egg laying.

22. Cluster flies (along with houseflies, face flies, some blowflies, and flesh flies) are referred to as "attic flies" because they often overwinter as adults in unused attics.

    A. True

    B. False

23. Cluster flies can be a nuisance inside buildings on warm winter days.

    A. True

    B. False

24. List at least three pest management procedures for controlling attic/cluster flies.

25. Describe a pest management scenario for house flies/blowflies in which you inspect the area around the structure, recommend sanitation and exclusion methods, and apply a pesticide.

26. List at least three pest management procedures for fruit fly or *Drosphila* infestations.

27-32. Match the following to the appropriate description.

    A. Moth or drain flies

    B. Fungus gnats

    C. Midges

    _____ 27. Infest flowerpots.

    _____ 28. Long, drooping antennae.

    _____ 29. Manipulate lights to reduce attraction.

    _____ 30. Larvae live in gelatinous material.

    _____ 31. Clean out sewage plant filter beds to control.

    _____ 32. Larvae live in water.

33. Pesticide application alone, without proper sanitation, will be enough to control fly pests.

    A. True

    B. False

SECTION 3

CHAPTER 12

STINGING PESTS

LEARNING OBJECTIVES

After completely studying this chapter, you should be able to:

- Identify common stinging insect pests.
- Describe the life cycles, habits, and habitats of yellow jackets, paper wasps, mud daubers, honeybees, and carpenter bees.
- 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 many of their relatives pollinators of flowering plants, including fruits and vegetables, but thousands of species of small wasps are parasites of pest insects. Without these parasites that limit the growth of insect populations, pests would overtake most crops.

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—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.

WASPS, YELLOW JACKETS, AND HORNETS

In parts of the United States, particularly in the eastern states, yellow jackets, wasps, hornets and bees are all called "bees" by the general public. Knowledge of the behavior of the various Hymenoptera is essential for their management. Effective communication with frightened or, at best, fearful clients is an important skill technicians must develop.

Nests of stinging pests are usually the targets for control. Understanding nesting and the makeup of the colony is essential.

Figure 12.1. Yellow jacket nest.

PAPER WASPS *(Polistes* spp.*)*

Paper wasps, along with yellow jackets and hornets, are in the insect family Vespidae. The common paper wasp, with its umbrella-shaped nest or single comb, best demonstrates the basic building pattern of a colony.

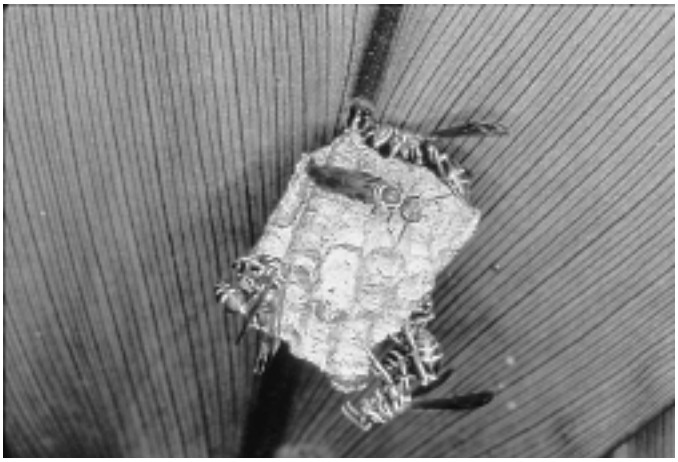


Figure 12.2. Paper wasps construct paper nests from wood that they chew into pulp.

The paper wasp queen, as is true of other vespids, 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 shaped with her mouthparts.

Figure 12.3. Paper wasps, *Polistes* spp., of the family Vespidae, are social wasps. Also included in this group are hornets and yellow jackets.

When a 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 in 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, chew through their silk cell cap, 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.)

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, these wasps sting people who venture into the same area. Colonies in trees, hollow fenceposts, and other protected places are not as easy to control as those on structures.

Habitat Alteration

- 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.

Pesticide Application

- Use pressurized sprays that propel spray for 8 to 12 feet or use aerosols on extension poles especially manufactured for aerosol cans.
- If a ladder is needed, wear a protective suit and veil. Proceed cautiously.

YELLOW JACKETS *(Vespula* spp.*)*

Yellow jacket colonies (18 species in North America) begin with a large fertilized queen. She develops smaller daughter workers and, later on, reproductives just as the paper wasps do, but the nest structure is not the same. Some yellow jacket nests hang in trees and shrubs, and some are developed underground.

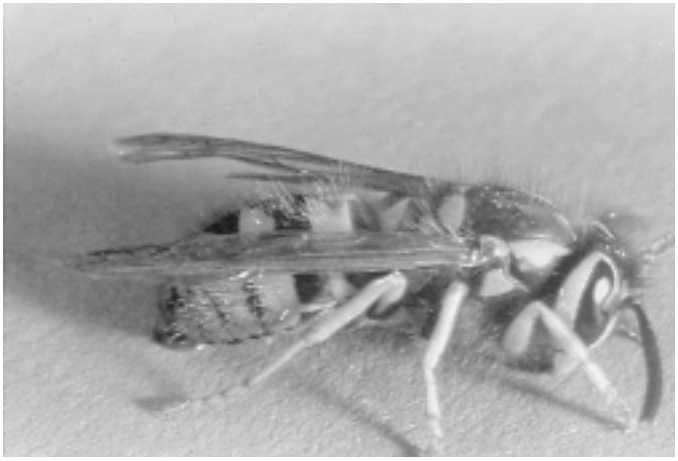


Figure 12.4. Yellow jackets, *Vespula* spp., are social wasps of the family Vespidae.

Aerial Nesters

Several yellow jackets make the aerial football-shaped paper nests commonly called hornet's nests. Two of these yellow jackets are common: the aerial yellow jacket, *Dolichovespula arenaria,* and the bald-faced hornet, *Dolichovespula maculata.*

The **aerial yellow jacket** is found in Canada and in the western and eastern United States (but not in the central and southern states). This species begins its nest in March or April and is finished and no longer active by the end of July. Their nests, usually attached to building overhangs, are smaller and more round than those of other species.

The **bald-faced hornet** is larger than the other yellow jackets and is black and white, not black and yellow. It lives along the West Coast, across Canada, and in all of the states in the eastern half of the country.

On warm spring days, the large aerial nesting queen, like the paper wasp, develops a small comb with a dozen or so cells, but she encloses it in a round, gray, paper envelope. The daughter workers later take over the nest duties, and by midsummer, when the worker population is growing and food is plentiful, the nest is expanded to full size. A full-sized bald-faced hornet nest consists not of a single umbrella comb like the paper wasp nest, but of four to six wide circular combs, one hanging below another and all enclosed in an oval paper envelope consisting of several insulating layers. Bald-faced hornets not only gather flies but are large enough to kill and use other species of yellow jackets for larval food. They attach their nests to low shrubs or high in trees or on buildings. Although aerial colonies can have 400 to 700 workers at one time, their food-gathering habits do not routinely bring them in contact with humans. Large nests are often discovered only after leaves have fallen and the nests are exposed—both to view and to nature's elements, which finally bring about their disintegration.

Figure 12.5. Bald-faced hornet, family Vespidae

Figure 12.6. Bald-faced hornet nest.

Underground Nesters

The stinging wasp, often identified as a yellow jacket, is black and yellow. Primarily yellow bands cover a dark abdomen. These species are in the genus *Vespula.*

They begin their nests like the aerial nesters—with an enveloped small comb made of wood fiber paper. Only these nests are started in soil depressions, rodent burrows, or in any small hole in the ground that will give protection until workers can develop.

Once workers begin nest care, they enlarge the entrance hole and expand the nest. Combs are placed in tiers, one below the other. They can be very large. They have firm support from the soil surrounding the external envelope. Several species of Vespula make their nests in building wall voids, attics, hollow trees, and other enclosed spaces, as well as in the ground.

Both Aerial and Ground Nesters

Of the thirteen species in North America, only a few require management. These few species have certain

characteristics and habits that put them on a collision course with people:

- They can live in what might be called disturbed environments (areas that have been changed to suit human activities in urban settings), such as yards, golf courses, parks, and other recreation areas.
- They have large colonies—some will develop thousands of workers.
- Their habits do not restrict them to a specific kind of prey. Foraging workers capture insects for their larvae and nectar and other sweet carbohydrates for themselves where they can find it them. Essentially, they are scavengers and work over garbage cans and dumpsters. They especially enjoy picnics and football games.

One can easily see that these habits put a large number of foraging stinging insects into close association with large populations of humans.

Common Yellow Jacket *(Vespula vulgaris)*

V. vulgaris ranges across Canada and the northeastern United States. Common in higher elevations, it nests in shady evergreen forests around parks and camps in the western mountains and the eastern Appalachians. This species also is one of the most important stinging insects in Europe.

Eastern Yellow Jacket *(Vespula maculifrons)*

This common ground-nesting yellow jacket is distributed over the eastern half of the United States. Its western border is from eastern Texas north to eastern North Dakota. Workers are slightly smaller than most other yellow jackets, but colony size can number around 5,000 or more individuals. The nest of *V. maculifrons* is dark tan, made of partially decomposed wood, and is quite brittle. The eastern yellow jacket sometimes nests in building wall voids.

Most yellow jackets have very slightly barbed stingers but the sting will not set in the victim's tissue as the barbed stinger of the honeybee does. The stinger of *V. maculifrons,* however, often sticks and when the insect is slapped off, the stinger may remain. When a stinger is retained, the insect cannot always be assumed to be a honeybee.

German Yellow Jacket *(Vespula germanica)*

In Europe, German yellow jacket nests are subterranean, but in North America the vast majority of reported nests are in structures. This yellow jacket is distributed throughout the northeastern quarter of the United States. Nests in attics and wall voids are large, and workers can chew through ceilings and walls into adjacent rooms. The nest and nest envelope of this yellow jacket are made of strong, light gray paper. Colonies of this yellow jacket may be active in protected voids into November and December when outside temperatures are not severe.

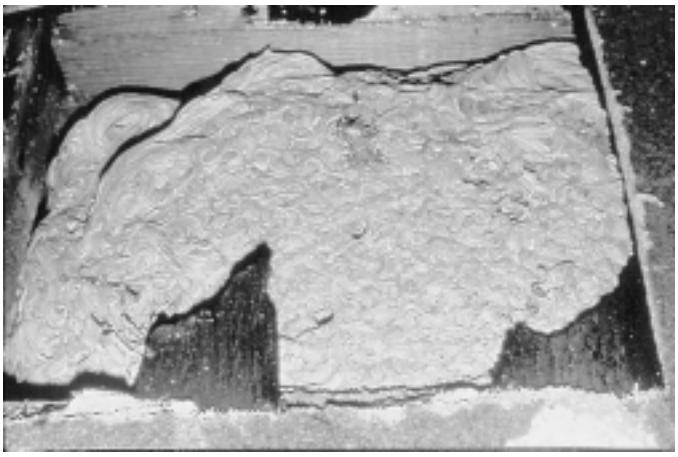


Figure 12.7. German yellow jacket nest in attic.

CONTROL AND MANAGEMENT OF YELLOW JACKETS

Problems with yellow jackets occur mainly when:

- Humans step on or disturb a colony entrance.
- A colony has infested a wall void or attic and has either chewed through the wall into the house or the entrance hole is located in a place that threatens occupants as they enter or leave the building.
- Worker yellow jackets 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.

Yellow jackets are sometimes responsible for injections of anaerobic bacteria (organisms that cause blood poisoning). When yellow jackets frequent wet manure and sewage they pick up the bacteria on their abdomens and stingers. In essence, 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 yellow jacket stings occur.

Inspection

Sting victims often can identify the location of yellow jacket nests. Where the nest has not been located, look in shrubbery, hedges, and low tree limbs for the bald-faced hornet. Soil nests are often located under shrubs, logs, piles of rocks and other protected sites. Entrance holes sometimes have bare earth around them. Entrance holes in structures are usually marked by fast flying workers entering and leaving. Nests high in trees should not be problems. ***Be sure to wear a bee suit and tape trouser cuffs tight to shoes.***

Habitat Alteration

Management of outdoor food is very important.

- 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 strategically 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 trashcans ***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.

Pesticide Application

When possible, treat ground and aerial nests after dark when workers are in the nest. More often than not, because of traditional work schedules, treatment will be scheduled for the daytime.

Begin with the entrance hole in view and a good plan in mind.

- Wear a protective bee suit. Unless these insects can hold on with their tarsal claws, they cannot get the leverage to sting. Bee suits are made with smooth rip-stop nylon that does not allow wasps and bees to hold on. A bee veil and gloves are part of the uniform. Wrist and ankle cuffs must be taped or tied to keep the insects out of sleeves and pant legs.
- Move slowly and with caution. Quick movements will be met with aggressive behavior. Move cautiously to prevent stumbling or falling onto the colony.
- Have equipment handy so one trip will suffice.

Application

- Insert the plastic extension tube from a pressurized liquid spray or aerosol generator in the entrance hole; release the pesticide for 10 to 30 seconds. If the pressurized liquid spray includes chemicals that rapidly lower nest temperature (freeze products), be aware that it will damage shrubbery.
- Plug the entrance hole with dusted steel wool or copper gauze. Dust the plug and the area immediately around the entrance. Returning yellow jackets cue on entrance holes using surrounding landmarks and seeing the shadowed opening. They will land at the entrance and pull at the plug, picking up toxic dust. Any still alive inside will also work at the dusted plug.

Aerial Nests

- Cut aerial nests down and seal them in a plastic bag. The queen and workers inside will be dead, and larvae will fall out of their cells and die from either insecticide poisoning or starvation. Pupae in capped cells may escape the treatment, however, and emerge later.
- Be especially cautious when using ladders to get at aerial nests or wall void nests. Set the ladder carefully and move slowly.

Wall Voids

- Approach the entrance hole cautiously; stay out of the normal flight pattern.
- Watch first. Observe whether yellow jackets entering the nest go straight in or to one side or the other.
- Insert the narrow-diameter plastic tube in the hole in the observed direction of entrance and release pesticide for 10 to 30 seconds.
- Dust inside the entrance and plug it as with underground nests.
- Remember, German yellow jacket colonies may remain active into December.
- Use care not to contaminate food surfaces.

Spraying trashcans and the outside of food stands will reduce or repel yellow jackets at sporting events. The treatment will not last more than one day. Honeybees are also killed with this control measure. Remember, do not contaminate food surfaces.

Follow-up

On-going monitoring throughout the active yellow jacket season is essential when a pest management program is in place at parks, recreational areas, zoos, and other outdoor activity areas.

HONEYBEES *(Apis mellifera)*

The honeybee was introduced into the United States in colonial times. Honeybees are highly social insects and communicate with one another, relaying direction and distance of nectar and pollen sources. Bees make combs of waxen cells placed side by side that provide spaces to rear young and store honey. The bee colony lives on the stored honey throughout winter and, therefore, 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, but they occasionally work their way into building wall voids.

Figure 12.8. Honeybee, *Apis mellifera.*

Figure 12.9. Honeybee swarm.

A honeybee colony in a house wall can cause major problems. The bees can chew through the wall and fly inside. Their storage of large amounts of honey invites other bees and wasps. Their detritus (e.g., dead bees, shed larval skins, wax caps from combs, and other material) attracts beetles and moths.

Figure 12.10. Honeybee combs in wall of house.

When a bee colony is found 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 nest in the wall to assure that the whole colony is treated.

After the colony is dead, remove the nest. If the nest is not removed, the wax combs—normally cooled by the bees—will melt and allow honey to flow down through the walls. Honey stain can never be removed—the walls will have to be replaced. As well, the freed honey attracts robber bees and wasps. The comb wax will attract wax moths, which may persist for several years. The dead bees attract carpet beetles.

After the colony is killed, the entrance hole should be caulked or repaired to prevent further bee infestation.

CARPENTER BEES (*Xylocopa* spp.)

Carpenter bees are solitary insects that live only one year. The most common carpenter bee, *Xylocopa virginica,* is distributed throughout the eastern half of North America. This bee is a large insect with a hairy yellow thorax and a shiny black abdomen. Superficially, it resembles yellow and black female bumblebees, which are social and more closely related to honeybees. Western carpenter bees are also large, shiny, sometimes metallic, and are shaped like bumblebees.

Figure 12.11. Caprenter bee, *Xylocopa* spp.

Carpenter bees bore in wood and make a long tunnel provisioned with pollen and eggs. They prefer to enter unpainted wood and commonly tunnel in redwood and unpainted deck timbers. They will also go into painted wood, especially if any type of start hole is present. New females reuse old tunnels year after year. They are also attracted to areas where other females are tunneling. Egg laying and tunnel provisioning occurs in the spring. Males hover around the tunnel entrance while the female provisions the nest and lays eggs.

Figure 12.12. Carpenter bee damage.

Males dart at intruders belligerently but they can do no harm—they have no stingers. Because these bees are not social, there is no worker caste to protect the nest. Stings by females are rare.

New adults emerge after the middle of summer and can be seen feeding at flowers until they seek overwintering sites, sometimes in the tunnels.

Control and Management of Carpenter Bees

Carpenter bees drill into the end grain of structural wood or into the face of a wooden member, then turn and tunnel with the grain.

Dust tunnels or inject with pressurized liquid insecticide. Insert a dusted plug of steel wool or copper gauze in the tunnel. Fill the opening with caulk, wood filler, or a wooden dowel. A dusted plug stops new adults that otherwise would emerge through shallow caulking. Caution should be taken, especially if technicians are working on ladders and if they are not experienced with these rather harmless bees.

MUD DAUBER WASPS AND CICADA KILLER WASPS

Family Sphecidae

Mud dauber wasps and cicada killer wasps are not social insects like paper wasps. They are in a different family. Many mud daubers paralyze spiders to provision mud cells built to enclose eggs, larvae, and pupae. The mud cells form long clay tubes or large lumps. The mud dauber wasps are slender, shiny black or brown, orange or yellow, with black markings. Many have long, thread-like waists.

There is no protective worker caste. These wasps are not aggressive and they will not sting unless pressed or handled. Mud daubers place their mud nests in protected places such as electric motors, sheds, attics, against house siding, and under porch ceilings. So many wasps congregate at the same site to construct the mud nests that later removal of the nests and repainting is often expensive.

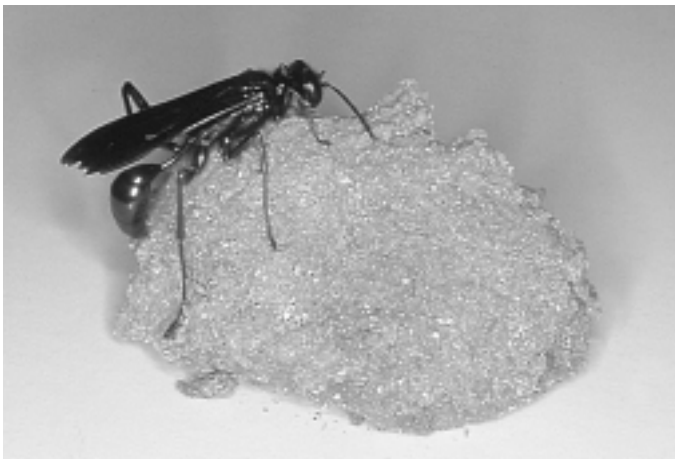


Figure 12-13. Mud dauber wasp, family Sphecidae.

Mud daubers are killed easily with aerosol contact sprays. Scrape away mud nests, and cover problem areas with a good quality smooth paint. Nesting should be discouraged on porticos and high porches of historically important buildings.

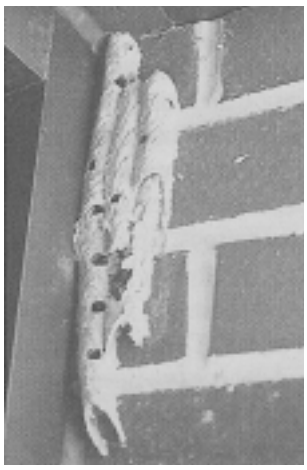


Figure 12.14. Mud dauber nest. Female mud daubers construct mud cells that they provision with spiders or insects as food for their young.

Cicada killers are very large yellow and black relatives of mud daubers. However, they do not look like mud daubers. More than 1 inch long, they look like "monster" yellow jackets.

Despite their large size, cicada killers can be ignored. Female wasps can sting, but stings are extremely uncommon. When there is undue worry about these huge wasps, open soil burrows can be dusted individually. The female will be killed when she returns.

Figure 12.15. Cicada killer wasp, family Sphecidae.

SUMMARY

Bees and wasps are part of the very large order Hymenoptera. Hymenoptera undergo complete metamorphosis and thousands of species are parasites of other insects. When they parasitize pest insects, humans list them as beneficial insects. In many instances, they are encouraged, protected, or reared and released for their pest suppression qualities. Many species of Hymenoptera are social, including stinging insects such as yellow jackets, paper wasps, and honeybees as well as the ants. Stinging social insects (with the single queen) can be very aggressive because there are many workers that can be used to protect the hive at the expense of their life. Stinging non-social Hymenoptera such as mud daubers, cicada killers, and carpenter bees tend to be non-aggressive and are usually single fertile females or queens that do not have a colony or a protective caste with individuals that can be expended.

SECTION 3 CHAPTER 12

Review Questions

Chapter 12: Stinging Insects

Write the answers to the following questions and then check your answers with those in Appendix A in the back of this manual.

1. What is the principal target for control of wasps, yellow jackets, and hornets?
   A. Larvae
   B. Eggs
   C. Nests
   D. Queen
   E. Workers

2. What are the two principal nesting habits of yellow jackets? Describe how nests are built.

3-12. Match the following to the appropriate description.

A. Paper wasp
B. Bald-faced hornet
C. Common yellow jacket
D. Eastern yellow jacket
E. German yellow jacket
F. All of the above

_____ 3. Nest is four to six wide circular combs, one hanging below another; enclosed in an oval paper envelope.

_____ 4. Aerial nester, more common in higher elevations.

_____ 5. Ground nester, sometimes in wall voids; nest made of partially decomposed wood.

_____ 6. Umbrella-like aerial nest consists of a single paper comb layer, no envelope.

_____ 7. Belong to the family Vespidae.

_____ 8. Have stingers.

_____ 9. Larger than other yellow jackets, black and white.

_____10. Queens and workers are the same size.

_____11. Mostly a ground nester in Europe; nest in attics and wall voids in North America.

_____12. Stinger, unlike other yellow jackets, may remain in the victim.

13. Which stinging pest would you NOT find nesting in a wall void?
   A. Eastern yellow jacket
   B. German yellow jacket
   C. Honeybee
   D. Paper wasp

14. List at least three pest management procedures for controlling paper wasps.

15. When do yellow jackets become a pest problem for people?

16. Clients should be informed that it is not possible for them to contract blood poisoning from the stings of yellow jackets.

    A. True

    B. False

17. List at least four habitat alterations for controlling yellow jackets.

18. When applying pesticides to control yellow jackets it is important to:

    A. Wear a protective suit.

    B. Move quickly to avoid stings.

    C. Avoid plugging the entrance hole.

    D. Cut nest down before spraying.

    E. A & B

19. Describe the procedure for applying pesticides for controlling aerial-nesting yellow jackets.

20. How is steel wool used in management of stinging pests?

21-26. Match the following to the appropriate description.

    A Honeybees

    B. Carpenter bees

    C. Mud dauber wasps

    D. Cicada killer wasps

    _____ 21. Paralyze spiders to feed young.

    _____ 22. Make tunnels; egg laying in spring; males have no stingers.

    _____ 23. Look like "monster" yellow jackets but are relatively harmless.

    _____ 24. Very important to remove nest after killing.

    _____ 25. Control, if necessary, by dusting open soil burrows.

    _____ 26. Permanent wall stains a potential problem.

27. What do mud dauber wasps have in common with carpenter bees?

    A. Non-social insects (no worker caste).
    B. Bore into wood.
    C. Nest can be scraped away.
    D. All of the above
    E. None of the above

28. Describe the procedure for managing carpenter bee infestations.

SECTION 3

CHAPTER 13

SPIDERS

LEARNING OBJECTIVES

After completely studying this chapter, you should be able to:

- 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. But some spiders when found in or around structures, are considered pests, especially those that are poisonous. 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 have very large eyes. Like all arachnids, spiders have no antennae.

Though all spiders are poisonous to some extent, few bite humans. Spider mouthparts, located in front below the eyes, have two short, needle-tipped appendages called ***chelicerae.*** These needles, or central fangs, are connected internally to poison sacs. The fangs are used to bite prey (mostly other arthropods) and inject poison to immobilize it. Two short, leg-like mouthparts help hold the paralyzed prey while the chelicerae work back and forth, tearing the exoskeleton. As blood wells out, it is sucked into the mouth cavity and ingested. Spiders keep working their prey in this way until all the juices are gone and the remainder is a dry, crumbled lump.

The abdomen is located behind the cephalothorax. It is saclike, usually globular. The anal opening is located near the end of the abdomen, and close by are some short appendages called the ***spinnerets.*** Silk webbing threads out from these spinnerets.

All spiders produce silk, and they use silk in more interesting ways than most other silk producers. Some spiders make silk retreats such as tubes and funnels. Others make irregular cobwebs or the evenly spaced, spiraled great orb webs. Most spiders feed out a dragline wherever they walk and never fall off edges without catching themselves.

Spiders don't have wings, but they "fly" nonetheless, by releasing a thread of silk until it is long enough for the wind to catch it and carry them off. The process is known as ballooning. 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 *(Latrodectus mactans)*

The black widow spider, *Latrodectus mactans,* is distributed over the eastern and southern United States. Travelers from other states introduced this species to Michigan. The native Michigan species is called the northern widow *(L. variolus).*

Female black widows have large, round, shiny black abdomens usually decorated 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 don't touch, but this ½-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 13.1. Black widow spider, *Latrodectus mactans.*

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 technicians are not commonly called on for black widow spider control, they may well run into these spiders when inspecting crawl spaces, porches, garages, and sheds for other pests. Black widow spiders can be found in stacked pots or 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 such as headache, dizziness, shortness of breath, and 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 the Black Widow Spider

Habitat Alteration

Eliminate harborage sites carefully.

Pesticide Application

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 (see Chapter 12). They paralyze spiders and store them in their mud cells for their larvae to devour.

BROWN RECLUSE SPIDER *(Loxosceles reclusa)*

Loxosceles reclusa is a dusky tan or brown spider with the widest range of any recluse spider in the United States. It ranges from central Texas north to Oklahoma, Kansas, and Iowa, and south through Illinois, North and South Carolina, northwestern Georgia, and Alabama, with a few collections in adjacent states and where they have been transported in luggage and household furnishings. Other species of recluse spiders live in the Southwest, particularly in desert areas. This spider lives outdoors in the southern part of its range and primarily indoors throughout the rest of its distribution. It is commonly found in older homes in the Midwest. The brown recluse is smaller than the black widow. 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.

Figure 13.2. Brown recluse spider, *Loxosceles reclusa.*

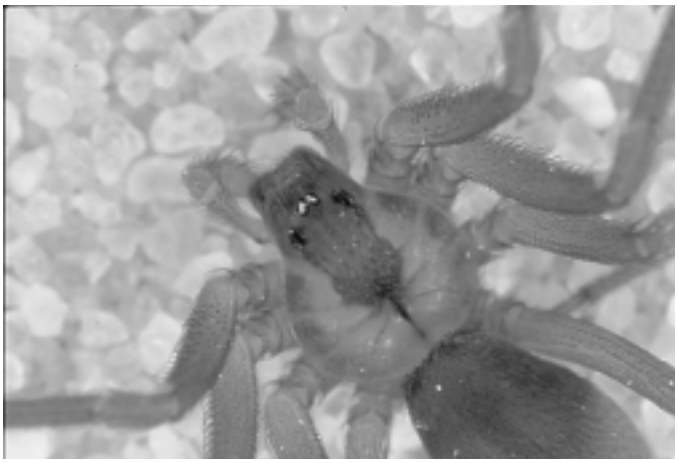


Figure 13.3. Fiddle-shaped mark on the cephalothorax of the brown recluse spider.

Bites. Recluse spiders avoid parts of rooms where human activity is prevalent, remaining where there is no activity and in closed 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, but a blister is quickly raised, broken, and 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 psychologically traumatic.

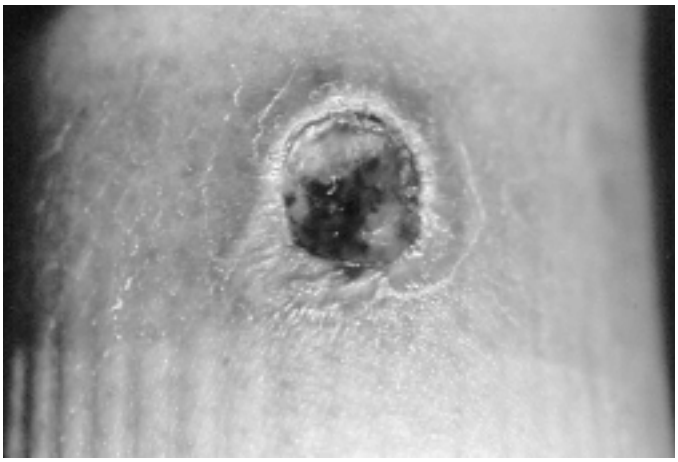


Figure 13.4. Brown recluse spider bite.

The spider is delicate. After biting, it frequently can be found lying where it was slapped by the victim. It should be killed and taken to the physician along with the victim for positive identification. Other biting arthropods can produce lesions resembling the bite of the brown recluse spider.

Control and Management of the Brown Recluse Spider

Inspection

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.
- Outdoors, in the southern and western part of its range, these spiders may be found in cracks between the soil and structure foundations, door stoops, and in window wells.
- Outside of their range, inspect around luggage, trunks, and furniture brought from southern Europe, the Mediterranean, or North Africa. American personnel, who have lived overseas in these areas sometimes introduce *L. rufescens* in returning household goods.

Habitat Alteration

- 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. Kill moving spiders.

Pesticide Application

- 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.

Follow-up

Spiders not killed by the pesticide treatment will wander. Warn clients to be wary of immediate use of rooms not normally in use. They should watch carefully for spiders one or two days following treatment. Monitor and, if indicated, retreat the structure in one or two weeks.

YELLOW HOUSE SPIDER
(Chirocanthium mildei)

The yellow house spider was introduced into the United States in the late 1940s and is now common. The native species is common outdoors. These spiders are about 1/4 inch long, with legs and cephalothorax darker than the abdomen. It has been reported as being yellow, white, or greenish.

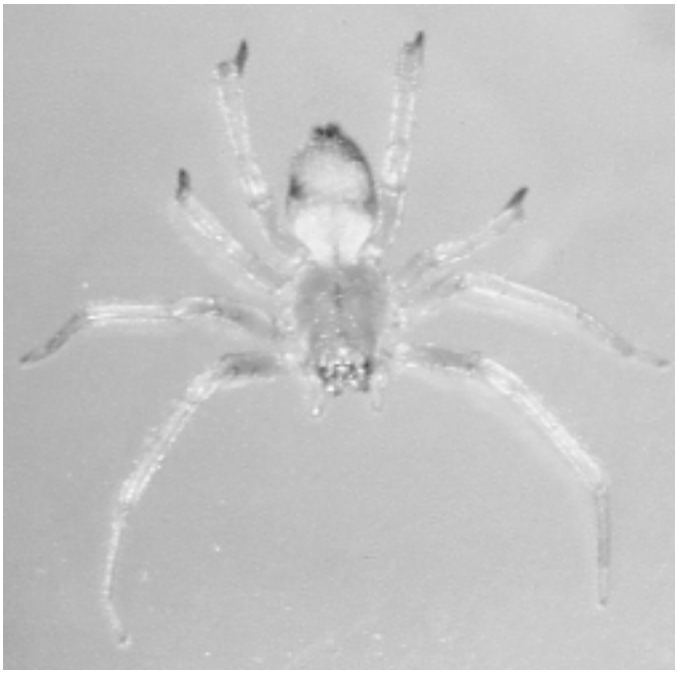


Figure 13.5. Yellow house spider, *Chirocanthium mildei.*

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

The yellow house spider will bite if pressed or accidentally confined (e.g., during the victim's sleep). The venom has been described as causing pain and reddening at the site of the bite. In some instances a deadening of the tissue will occur, but it is much less severe than that caused by the brown recluse spider. Children that show symptoms of spider bites (the two fang marks) may have been bitten by the yellow house spider. This spider, however, cannot pierce the skin of everyone. There is a very large margin of safety.

Control and Management of the Yellow House Spider

Inspection

- Inspect rooms, particularly bedrooms of suspected yellow house spider bite victims. Inspect obvious webbing sites in the fall as a part of on-going monitoring activities for other pests.
- Look at the angles of the wall and ceiling, door and 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 transition period. Other sites are gas stoves and refrigerators in recreational vehicles, gas air conditioners and through-the-wall gas furnaces. The silken obstructions interfere with gas flow; operational failure can be an indication of their presence.

Habitat Alterations

- Close gaps around outside entry doors and ground floor windows that may be entry points for the spider.
- Keep grass low next to building foundations to discourage wandering spiders.

Pesticide Application

- 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.

WEB-WEAVING SPIDERS

Orb-weaving Spiders

Several hundred species of orb weavers are distributed in the United States. Usually only the large, conspicuous orange and yellow or black and yellow species are noticed in late summer when they build webs that extend 1 foot or so across on porches or small trees and shrubs. These large flat webs have many straight strands radiating out from the center and are connected with spiral thread winding around and around from the middle out to the perimeter. The spiders, often with bodies 1 inch long and very long legs, sit in the center of the web waiting for flying insects to be trapped. The large orb weavers

Figure 13.6. Orb-weaving spider.

are not aggressive towards people. If the client's fear is great, the webs can be knocked down.

Smaller orb-weaving spiders build webs across paths in the woods. Another web builder, the barn spider, *Araneus cavaticus,* is the prominent, non-aggressive character in the children's book *Charlotte's Web.*

Cobweb Spiders

Cobweb-weaving spiders make small, irregular webs. These webs are characteristically found indoors in the upper inside corners of window frames. There are many species of cobweb spiders and the black widow is one of them. Most of them are smaller than the black widow. They have the same type of globular abdomen, but it is always dull in color and not as eye catching. These quiet spiders hang in the web and wait for small insects to wander into their snares.

The problem with cobweb spiders inside buildings is that when they feed, they defecate drops of feces that dry and discolor anything they fall on. These spots are difficult to remove from painted wooden trim. Regular dusting eliminates cobweb spider problems. In historically significant buildings and museums, their presence should be called to the attention of building supervisors.

Spiders in Boathouses

A unique but not uncommon spider habitat is the rafter areas of boathouses. Ballooning spiderlings trailing their silk threads are taken up by the wind and deposited on boathouse uprights and piers. When they crawl up into sheltered spaces, they find it is also a refuge for flying insects such as flies and gnats. When they feed, their feces fall on the painted roughened decks of pleasure boats. Like those from the droppings of the housebound cobweb spider, these spots are extremely difficult to remove.

This perplexing problem is abated somewhat if the spiders' food source is eliminated. Locate lights so they will not attract flying insects to the boathouse. Flies and gnats do not rest in breezy areas, so fans activated at night may also help.

- Careful placement of electric fly grids outside the roof area may reduce gnats. Avoid placement that draws flies or attracts midges from distances.
- Fogging inside the roof only causes the spiders to drop out of the fogged area on their webs and return when the fog is ventilated.
- Do not use residual pesticide spray applications. They are almost certain to drop on the water and cause contamination. Spray applications also degrade rapidly in heat.
- Sticky tapes or papers for fly control will liquefy in the heat of these shelters and also drop on boats below.

Spiders on Monuments

Spider buildup on buildings and monuments can cause major problems for structural maintenance. Where structures are lighted near aquatic areas in certain seasons, midges are attracted to the light and drive the increase in spider populations. Large spider populations harm limestone and marble structures and statuary with feces and webbing.

When this occurs:

- Pesticide use is not effective. Explore habitat alteration.
- Locate the source of midge populations and identify their habits of emergence, egg laying, etc.
- Record flight times and periods. Time lights to turn off during the main flight period. Alternative placement for lighting should be considered as required for public safety.

WANDERING SPIDERS

Wolf Spiders

The hairy, fleet, wolf spiders are very common outdoors under leaf litter, rocks, and logs. When they come inside, they normally stay on the ground floor and are active in dim light. Large wolf spiders often frighten people. If handled, they give a painful bite, but it is not dangerous.

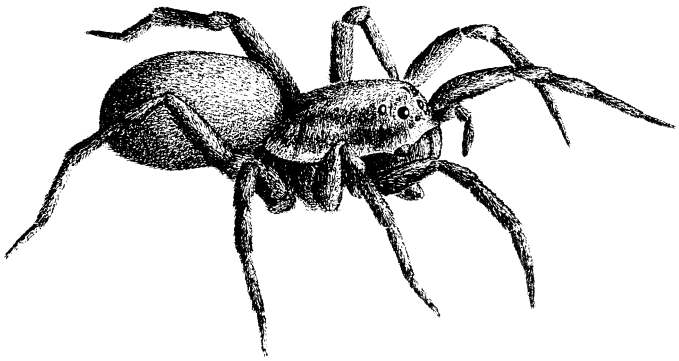


Figure 13.7. Wolf spider.

Jumping Spiders

Jumping spiders are active during the day and are common around windows, where they feed on insects attracted to natural light. Jumping spiders are usually small, up to $^1/_2$ inch in length. They have husky cephalothoraxes and are brightly colored, sometimes iridescent. They hold their front legs up in front of them when approached and move in quick rushes, jerks or jumps. They often enter buildings from shrubs near windows, or ride in on plant blossoms.

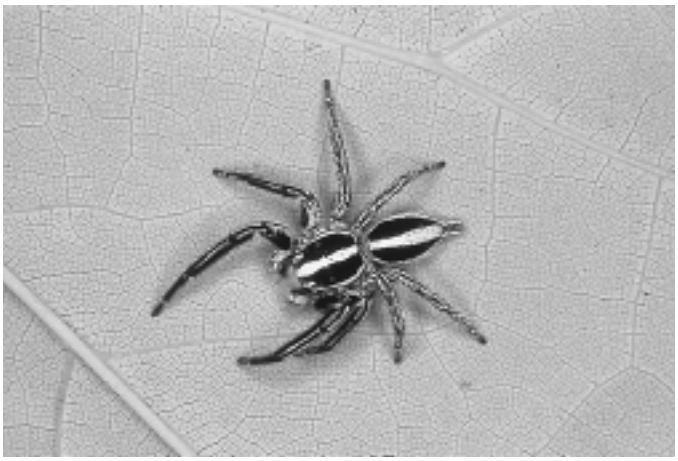


Figure 13.8. Jumping spider, *Plexippus* spp.

Crab Spiders

Small crab spiders are dark or tan. Some are lightly colored orange, yellow, or creamy white. Their legs extend out from their sides causing them to scuttle back and forth in a crab-like fashion. These spiders hide in flower blossoms and ambush insects. Some can even change their color to more closely match the flower's color. Crab spiders, like jumping spiders, are often brought inside in cut flowers that they abandon when food becomes unavailable. They can be pests wherever flowers are introduced.

Control and Management of Wandering Spiders

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

- Close up gaps under doors and around window screens.
- Caulk door and window frames and all wall penetrations.
- Remove vegetation and litter from the foundation, doorways, and window wells.
- Turn off house, building, or area lights 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 without harm.

Pesticide application is very difficult. Indoor treatment is usually effective only if the pesticide contacts the spider directly. This means the technician must have clear access to all spider habitats. Unless efforts are made to exclude spiders (e.g., tighten gaps around entrances, and observe material being brought into the facility), spiders will reenter.

SUMMARY

Spiders are distinctive arthropods in the class Arachnida. They have two regions to their body—the front one is the cephalothorax, on which are located eyes, mouthparts, and four pairs of legs. The rear region is the abdomen, at the tip of which are located silk-spinning organs. Spiders, for the most part, live outside; some enter structures and dwellings. A few can deliver bites that are debilitating or even fatal. They spin webs in which to live or capture prey. These webs are considered unsightly indoors. For the most part, spiders are beneficial to humans, capturing and eating many insect pests.

SECTION 3
CHAPTER 13

Review Questions

Chapter 13: Spiders

Write the answers to the following questions and then check your answers with those in Appendix A in the back of this manual.

1-10. Match the following to the appropriate description:

A. Black widow spider
B. Brown recluse spider
C. Yellow house spider

_____ 1. Males small, striped yellow and red, harmless.

_____ 2. Violin-shaped design on cephalothorax.

_____ 3. Hang upside-down on web.

_____ 4. Abdomen with a red hourglass.

_____ 5. Blister raised immediately after bite; surrounded by a red welt that turns dark within a day; bite area scars over in one to eight weeks.

_____ 6. Abdomen tan-brown color, no distinctive markings.

_____ 7. The "most" poisonous.

_____ 8. The "least" poisonous.

_____ 9. Spiders overwinter in white, silken cocoon-like webs.

_____10. Bite is immediately painful.

11. Which insect can be a biological control for spiders (paralyzes spiders and feeds them to its larvae)?

A. Mud daubers
B. Spider mites
C. Eastern yellow jackets
D. German yellow jackets
E. Killer bees

12. Describe inspection procedures for black widow spiders.

13. Describe inspection procedures for brown recluse spiders.

14. Describe inspection procedures for yellow house spiders.

15. It is difficult to control black widow spiders with pesticides because the pesticide must directly contact the spider.

A. True
B. False

16. What would you advise a client to do after being bitten by a brown recluse spider?
    A. Kill and collect spider for identification.
    B. Kill spider and wait to see if symptoms develop.
    C. Seek medical help.
    D. Apply a salve to the bite area.
    E. A & C

17. Which type of pesticide application would be the best method for controlling brown recluse and yellow house spiders?
    A. Residual crack and crevice
    B. Spot treatments of residuals
    C. Contact sprays
    D. Aerosols/fogs

18. Which pest control method would be most effective at controlling black widow spiders?
    A. Crack and crevice
    B. Eliminate harborage sites
    C. Residual sprays
    D. Aerosols/fogs
    E. Caulking and screening

19. How do spiders enter structures?
    A. Under doors
    B. Through window wells
    C. With flowers brought inside
    D. All of these
    E. A and B only

20. A difficult problem with cobweb spiders indoors is:
    A. Aggressiveness towards people.
    B. They drop feces that discolor painted wood.
    C. Webbing is difficult to remove.
    D. They attract flies and gnats to their webs.
    E. C & D

21. Use residual spray applications of pesticides to control spiders in boathouses.
    A. True
    B. False

22. To reduce spider populations in boathouses and on monuments, control their food source.
    A. True
    B. False

23. List three types of wandering spiders and discuss methods to control them.

SECTION 3

CHAPTER 14

TICKS, MITES, BEDBUGS, AND LICE

LEARNING OBJECTIVES

After completely studying this chapter, you should

- Be able to identify common biting pests.
- Understand the life cycles, habits, and habitats of biting pests.
- Know which biting pests transmit diseases.
- Know what precautions to take to prevent disease transmission.
- Know integrated pest management options for biting pests.
- Know what to do in the case of imaginary pest infestations.

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

In many of the pest situations discussed in this chapter, pesticide application will not be necessary. Habitat alteration is often all that is needed to manage biting pests. It is important that pest control technicians understand the habits, life cycles, and disease-vectoring capabilities of biting pests so that clients receive the proper advice. For example, knowing when to advise a client to seek medical attention is crucial. Furthermore, fear of parasitism and/or unfavorable environmental conditions can lead to imaginary pest infestations. This chapter discusses how pest control technicians should approach these situations. Clients' fears and concerns should not be discounted. A thorough investigation should be conducted to determine whether the pest infestation is real or imaginary.

TICKS AND MITES

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 and an abdomen that is connected behind, 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

Ticks, the largest mites, feed only on the blood of mammals, birds, reptiles, and amphibians. Ticks differ from other mites. Ticks are larger and have recurved

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 stimuli such as heat and carbon dioxide. Ticks also detect light and dark as well as shapes, shadows and vibrations—all stimuli that help them find their hosts.

There are two types of ticks: soft and hard. Soft ticks feed on hosts that return periodically to a nest, shelter, cave, coop, and so forth. Hard ticks are found on pets, cattle, wildlife and people. In the United States, campers, hikers, and hunters are sometimes hosts for hard ticks. Worldwide, there are over 650 species in this group.

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

Life Cycle

Seed Ticks. Normally, thousands of tiny larvae hatch from a batch of eggs and crawl randomly in the surrounding area. Fortunate ones attach to a small mammal or lizard. These larval ticks—called ***seed ticks***—suck blood. Being small, their feeding (or engorgement) time lasts only hours or a day or so. While feeding, the host wanders and seed ticks are distributed away from the site of the initial encounter. When the engorged seed ticks drop off, they are still usually in or near an animal run.

Nymph. After molting, the engorged nymph climbs grass leaves or a plant stem. Ticks climb progressively higher as they develop; different stages reach different layers of vegetation. Because of this, developing ticks usually find a larger host than they had during the previous stage. After several days feeding, the engorged nymph drops off its host and molts.

Adult. The adult climbs vegetation, stretches its front pair of legs, and waits for vibrations or a shadow 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 (e.g., from a feeding mouse), 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 from several days to more than a week. Anyone who removes an engorged tick gains, at least, a grudging 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 from a point relatively close to the ground: 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 pets, 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 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 from several days to a week or more—or in the case of human hosts, until the tick is discovered. When feeding is complete, the engorged female drops off of the host, lays eggs, then dies.

Male ticks are on the host to mate. They do not enlarge greatly or feed much. In fact, they sometimes pierce and feed on the engorged females. In one species, this is the only way males feed.

BROWN DOG TICK
(Rhipicephalus sanguineus)

The brown dog tick is the most urban of the pest ticks in the United States. It has been introduced around the world on dogs and other animals, but in the United States its only host is dogs. In the southern United States, the brown dog tick lives outdoors year round, but in most of the country it cannot live outdoors in winter.

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, larvae outdoors climb vegetation; when they are inside, they climb walls and furniture. The larvae, nymphs, and adults return to the dog to feed; they do not bite humans. If they do not find a host, they can easily wait more than 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.

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.

When 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. In fall, winter, and spring, tick infestations indoors are likely to be brown dog ticks.

Figure 14.1. Brown dog tick, *Rhipicephalus sanguineus*, male and female.

Ticks at each developmental stage drop from the host and seek cracks to hide in and molt. Brown dog 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

Inspection

- Look in rooms where dogs sleep—under the edges of rugs, under furniture; in cracks around baseboards, windows, and doorframes; in dog boxes.

Habitat Alteration and Pesticide Application

Advise clients to:

- 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.

Pest control technicians:

Inside:

- Use crack and crevice pesticide applications where ticks hide.
- Treat under the edges of rugs; under furniture; in cracks around baseboards, windows, and doorframes; in dog boxes.
- ***Do not allow pets or children in the sprayed area until it is dry.***
- Fogging for ticks is useless.

Outside:

- Spray or dust kennels and resting areas using pesticides labeled for that treatment.
- ***Do not allow pets or children in the sprayed area until it is dry.***

Follow-up

It is important that clients know that dogs should be protected even after treatment because eggs can take 30 days to hatch. Take time to assure clients that brown dog ticks do not bite humans and will therefore ***not transmit a disease.*** The fear of Lyme disease can drive a desire for overkill. Explain that the brown dog tick does not spread Lyme disease.

TICKS AND DISEASES

Several species of hard ticks are significant human disease vectors (or carriers) and are responsible for the spread and increase of Lyme disease and the persistence of Rocky Mountain spotted fever (RMSF). All technicians 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 from 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 disease, are increasing in both rural and urban areas. As well, urban tick populations are not susceptible to classical agricultural pesticide cover applications.

There are many reasons why ticks are successful parasites and successful at transmitting diseases.

- They are persistent bloodsuckers—they 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, later 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 (a spiral-shaped bacterium). Symptoms vary and may mimic other diseases; 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 the tick is located and removed within that time, no 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 with a clear center. This center often is the site of the bite. The rash may burn or itch. Technically, this rash is called erythema cronicum 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 with reddening of the whites of the eyes. Flu-like symptoms may accompany the skin symptoms—e.g., 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 experience an 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 symptoms 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 tick habitat. In fact, diagnosis of the disease in dogs in an area is a harbinger of human cases to follow. Symptoms in dogs include sluggishness and lameness.

Responses to Lyme Disease: Education

This serious disease can be expected to increase. Technicians should clearly instruct their clients that there are no easy or effective control measures that state or federal agencies can perform.

- Children are at highest risk. They encounter infected ticks in camps and parks, on hikes, or at play in areas where deer and mice abound. Children are not as sensitive to finding ticks on themselves as adults are.
- The second risk group consists of adults whose occupations place them in tick habitat: farmers, outdoor maintenance workers, park and forestry personnel, and military personnel.
- Members of the general public who hike, camp, participate in outdoor recreational sports, or live in areas of preferred tick and host habitat 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 a 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.

At least four to six hours elapse after the American dog tick begins feeding before disease transmission begins. If ticks are removed during this noninfective period, infection will not occur.

A rash on wrists and ankles, the most characteristic and consistent symptom of RMSF, occurs on the second to fifth day after infection. Often aching in the lower back and headaches around the head and eyes will also occur. Victims feel very tired and can run fevers of 104 to 106 degrees 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.

TICKS THAT CARRY DISEASE

Deer ticks, or *Ixodes* spp. carry Lyme disease. This genus of ticks contains the greatest number of species of the hard ticks and they transmit diseases around the world. The northern deer tick, *Ixodes scapularis,* is the carrier (called a vector) of Lyme disease in the eastern and midwestern United States. In the West, the common vector is *I. pacificus.* There are many other *Ixodes* in the United States, and what part they will play in Lyme disease transmission is not yet known.

The American dog tick, *Dermacentor variabilis* is the eastern, central United States, and Pacific coast vector of Rocky Mountain spotted fever. The Rocky Mountain wood tick, *Dermacentor andersoni,* which closely resembles *D. variabilis,* is found in the Rocky Mountain states, Nevada, eastern California, Oregon, and Washington. This tick was the original vector of Rocky Mountain spotted fever. When settlers reached the west, their dogs contracted RMSF from the wood tick and transmitted it to the American dog tick. The American dog tick then became the principal vector of the disease and has carried it around the world.

The lone star tick, *Amblyomma americanum,* ranges in the southeastern quarter of the United States from Texas to northern Missouri and east to New Jersey. The lone star tick can transmit Rocky Mountain spotted fever, but it is not as important an RMSF vector as the two species of *Dermacentor.*

Figure 14.2. Disease-carrying ticks—deer, lone star, and American dog.

DEER TICKS *(Ixodes scapularis)*

The deer tick is unlike the larger lone star tick and the American dog tick (see Figure 14.2). Larvae are no larger than the period at the end of this sentence. Nymphs are close in size to the adult—a little less than 1/16 inch, or the size of the head of a pin. Adult deer ticks are the size of a sesame seed. Deer ticks have a two-year life cycle and utilize three different hosts.

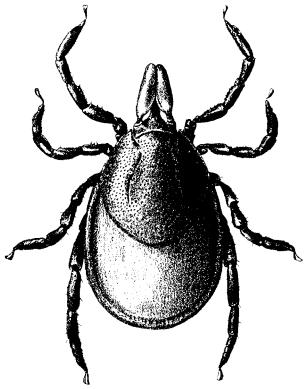
Eggs and Larvae. Adult tick females that have overwintered lay eggs in the spring. Tiny larvae hatch and feed on white-footed mice and other mice in the late summer. ***Larvae can feed on humans but will not transmit Lyme disease.*** Larvae overwinter, and in the following spring, they molt into the 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 classically called the "white-footed mouse habitat," where larvae fed the previous late summer. This habitat is best described as woodlands: bushy, low shrub woodland edge regions and grassy areas that border woodlands. This is also deer habitat. The mice travel in trails and nest almost anywhere they can find a sheltered depression. Nymphal tick activity coincides with human outdoor activity, and peak human infection 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 overwinter 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.



Adults feed on deer, which are unaffected by Lyme disease. Where these deer move while hosts of egg-laying females determines the distribution pattern of the next generation. 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.

AMERICAN DOG TICK *(Dermacentor variabilis)*

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

Only the adults, which are slightly over 1/8 inch long, are found 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.

With a favorable food supply, American dog ticks can complete their life cycle in three months, with the female laying 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 they are stopped by constricting clothing, such as belts or underclothing. Loose clothing worn by children allows ticks to proceed as far as the head hair. This is probably the basis for the false idea that ticks drop out of trees. Because of possible transmission of RMSF, any tick attachment should be noted and the victim observed for symptoms.

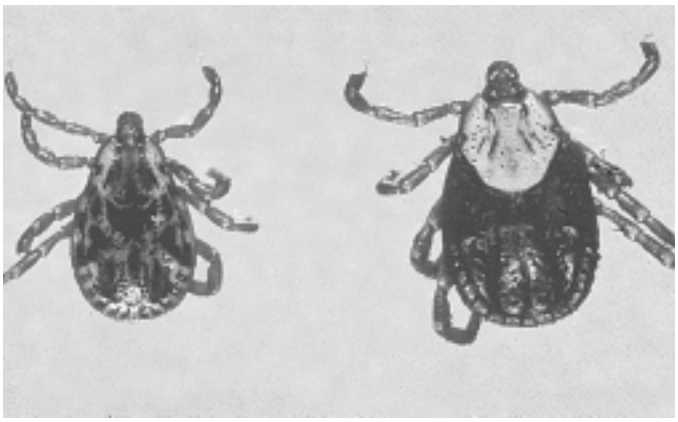


Figure 14.3. American dog tick, *Dermacentor variabilis*, male and female.

LONE STAR TICK *(Amblyomma americanum)*

The lone star tick lives in the southeastern quarter of the United States from Texas to Missouri and east to New Jersey. It attacks birds and both wild and domestic mammals, including humans.

Females are brown with a white spot in their center (the lone star). Males are mottled brown without a white spot. Both sexes have pigmented eyes at the front lateral edges of the scutum. Females are prolific, often producing more than 6,000 eggs.

Though it is rare to find larval ticks on humans, all three stages of the lone star tick will attack people. When the solid brown larval tick infests humans, it is usually the result of an unwitting person sitting or lying on an aggregation of larvae. Frequently, the infestation amounts to many, perhaps hundreds of ticks. These infestations of larval ticks are easily noticed and easily removed. Usually the larvae wander but do not attach. They can be showered off.

Lone star ticks are associated with cattle and deer, so human risk increases around large cattle and deer herds. When found on humans, the ticks certainly should be removed and noted, in case RMSF symptoms develop.

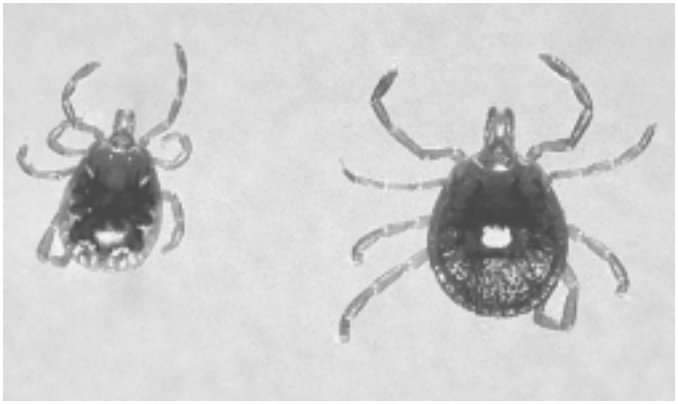


Figure 14.4. Lone star tick, *Amblyomma americanum*, male and female.

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 know what kinds of ticks are present, where they are most numerous, what the disease potential in the area is, and what the host and reservoir populations are. ***Pest management programs are critical for effective management of tick species that transmit Lyme disease or Rocky Mountain spotted fever.***

Inspection

- Drag a flannel rectangle, 2 by 3 feet, using a rope on a board at the front and a strip of wood at the back for weight. All stages of ticks attach to the flannel. Collect them and take them to a university Extension Service office for identification. An office is located in each county. Small pieces of dry ice (CO2) placed in the middle of cloth squares have also been successful in attracting ticks.
- 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 ascertain 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) prevalence. They also have information on disease prevalence in hunters and hunting dogs.

Habitat Alteration

Talk with game conservation personnel about game management practices and game habitat modification. Make recommendations.

- 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.
- Advocate 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.
- Keep vegetation short to eliminate rodent habitat in areas where people congregate.
- Advise that uncontrolled areas with high tick density be kept off-limits to the public.

Pesticide Application

A novel control measure using ***permethrin-treated cotton balls in cardboard cylinders*** has been reported to reduce tick populations. The 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.

- Spray 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 weeds where mowing is impossible. Remember, broad application of pesticides to mowed grass does not reduce tick populations because white-footed mice do not infest lawns.
- Dust rodent runs or burrows in areas where human traffic cannot be controlled and where there is a danger of disease transmission.

To control ticks on pets:

- Use insecticidal dips, washes, or dusts that can be obtained at pet counters or from veterinarians. Dogs should be protected if they roam in tick 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.

Follow-up

Continued monitoring and record keeping is important. Tick counts should be reviewed annually to evaluate and adjust the pest management program. ***Educational programs and materials for at-risk groups (children and outdoor workers and recreators) are vital.***

Precautions for At-risk Group Members

- Wear long pants tucked in socks while working or hiking in tick habitat.
- Use insect repellents on clothes and skin. Do not use formulations with over 20 to 30 percent active ingredient on skin.
- Use permethrin formulations that are labeled for use as a repellent on clothes. They withstand washing and remain effective.
- Sulfur powder dusted on socks repels chiggers. It also may be effective against ticks.
- Schedule regular body inspections for ticks at noon and at bedtime.
- Nymphal deer ticks are small, but they can be seen with close inspection. Larval deer ticks cannot be spotted easily, but they are not disease carriers.
- Only adult American dog ticks can infest both people and dogs.

Tick Removal

Regular inspection, location, and early removal of ticks prevents disease transmission.

To remove feeding ticks, ***dab them with alcohol.*** If feeding has just started, and mouthparts are not cemented in, ticks sometimes pull their mouthparts out.

If they do not release in a few minutes, ***take tweezers, grasp the tick at the skin level and pull steadily*** until the tick is removed. Grasping the tick by the back end, or heating it, can force disease organisms into the wound. Place the tick in alcohol or otherwise keep it for identification. ***If the mouthparts are left in the skin, they will not transmit the disease, but the wound should be treated with an antiseptic to prevent secondary infection.*** Note the date of removal to calculate the time of symptoms onset.

If the tick is identified as a deer tick, see a physician. If it is an RMSF carrier, look for symptoms within a week after exposure. If they occur, notify a physician.

MITES

Mites are more diverse than spiders. More than 30,000 species of mites have been identified. They are found all over the world, from deserts to rain forests, mountaintops to tundra, saltwater ocean floors to freshwater lakes. They suck plant juices and animal blood, make tumors (galls) in plants, and transmit diseases. Relatively few mites are parasites on humans or other animals.

Mouthparts are attached at the very front end of a mite's body. These mouthparts consist of a group of small appendages that sometimes looks like a head, but the brain actually is located behind the mouthparts and eyes. The mouthparts of mites form a tube that ingests plant or animal juices. Very short appendages on each side of the mouthparts guide other mouthparts as they are inserted into food tissues. As the mite sucks, digestive juices gush out of the front of the body, mix with the food juices in the mouth, and are sucked back through the mouth tube. The mite's genital opening is found underneath and between the attachments of the first two pairs of legs.

Mites walk by using body muscles to press blood into individual legs. The movement of blood extends a leg out or forward. Little muscles in each leg segment then pull the segment back, and the mite moves forward. Many mites use their first pair of legs like antennae, feeling in front as they walk along. Leg hairs have diverse purposes: some sense touch; others pick up odors; not uncommonly, some hairs have light-sensing cells that allow the mite to distinguish light from dark.

HUMAN ITCH OR SCABIES MITE *(Sarcoptes scabiei)*

Pest management technicians are sometimes asked to treat homes where scabies mite infestations have occurred. Pesticides should not be applied. Scabies mites are parasites of humans, dogs, pigs, horses, and sheep; the species of one host does not parasitize other hosts.

Scabies mites are microscopic. The only way to be certain of an infestation is to have skin scrapings made and inspected under a microscope. However, physicians with experience can usually make accurate diagnoses without laboratory procedures.

Infestation. Scabies are transmitted by direct contact only. Crowded conditions, particularly where children sleep together, spread scabies infestations most quickly. A scabies mite infestation begins when a fertilized female cuts into the skin and burrows in the upper layer of skin. She lays eggs in the burrows. Larvae hatch in the burrows and come to the surface to molt. Two nymphal stages and the adult stage are spent on the skin surface. Only fertilized females burrow beneath the skin surface.

Favored places of infestation include the skin between fingers, at the bend of elbows and knees, and under breasts. Though the idea of mite burrowing, even if it is only in the epidermis, might bring on itching, these sensations do not develop for a month after the initial infestation. It takes two or three generations with subsequent secretions and excretions to bring about sensitivity to burrowing.

Treatment. Treatment is relatively simple. Pesticide ointments or creams prescribed by physicians are applied from the neck down to every member of the family. Bedding and underwear is laundered. ***No pesticide application to rooms or objects is indicated under any circumstances.***

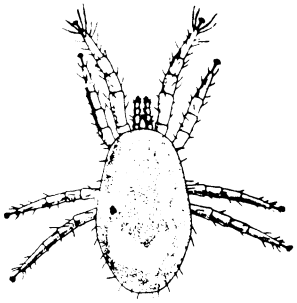
HOUSE DUST MITES
(Dermataphagoides spp.*)*

Though these microscopic mites are found in the United States, they are much more prevalent in England, where humidity is very high.

House dust mites sometimes cause allergic reactions. Cast skins and body parts of house dust mites accumulate with other dust and small household allergenic disintegrated matter. Vacuum intensely. A new and effective management method is to spray carpet with tannic acid solutions obtained from carpet cleaning suppliers.

BIRD MITES

Pest problems ranging from imaginary itches to pubic lice have been diagnosed as bird mites. Several species of mites bite and suck blood from birds. Smaller than a period, these rapidly moving mites are difficult to find. They may be very light colored, red, or dark, depending on their last blood meal. Their bites resemble small skin pricks. Hungry mites are not reluctant to bite.



Several populations of arthropods occupy bird nests. They make up their own community with physical and biological supporting factors. For this reason, bird mite control is a simple example of integrated pest management. Management is required of this entire small ecosystem.

Applicators will find predatory species that feed on mites: beetles that feed on feathers, textile pests that infest woolens, and beetles and mites that feed on fungi. This community of organisms is supported by the blood, feathers, down, and moist droppings of the birds.

When the young birds fledge (grow flight feathers and leave the nest), the food supply stops and the arthropod community leaves in search of other harborage. Often, bird mite migration can be tied to a particular bird species (usually one of the pest birds that nest on structures).

In the middle Atlantic states, bird mites become problems when fledgling starlings leave the nest in late May and early June. Suspected bird mite infestations at other times of the year more often than not turn out to be caused by other problems.

CONTROL AND MANAGEMENT OF MITES

Inspection

Always collect mites for identification.

- Use a small watercolor brush to pick them up.
- Store them in alcohol.
- Often mite activity is close to their point of entry into a structure. When this is the case:
- Look for bird nests on the outside of the structure on ledges, air conditioners, etc.
- Identify ways mites can enter buildings.

Habitat Alteration

In this case, habitat alteration also refers to the host birds' habitat.

- Remove nests.
- Screen or net nest areas.
- Install inclined ramps to prevent nest attachment.
- Prevent nesting.
- Caulk entrance points into structures.

Technicians should always protect the eyes and respiratory system from dust of the nest, bird droppings, and fungal spores when cleaning roost areas. Wear rubber gloves to keep mites from crawling on hands and arms.

Pesticide Application

Use pesticides labeled for mite control. Without food and with pesticide applications, mite activity should cease within one day. Activity for extended periods means that nests and entrances have been missed (or the pest was misidentified).

- Apply pesticides indoors to cracks and crevices in the area of mite activity.
- Apply sprays or dusts in the cracks that might communicate with the nest area.
- Outside, spray or dust pesticides at the nest area to kill wandering mites.
- Poultry mites, the same species or a close relative of bird mites, can be problems. These mite infestations are treated in poultry houses or coops.
- Obtain and follow recommendations from university or county Extension Service agents.

Follow-up

Record nest sites and control methods. If later infestations appear, new nests can be identified. Note the dates when identified bird mite infestations are reported. Keep records for several years; pinpoint times and seasons when these pests can be expected. Conduct annual monitoring of nesting sites before birds fledge.

BEDBUGS

The term "bug" is slang for insect. Used technically, however, it refers to the thousands of species of the order Hemiptera, "true bugs," which includes bedbugs. Most species of true bugs feed on plants; many feed on animals, other insects in particular; some are aquatic. Feeding is accomplished when the bugs pierce tissues with slender thread-like stylets (located in a "beak" on the front of the insect's head) and suck up liquids. Bedbugs are indeed true bugs that suck blood.

COMMON BEDBUG *(Cimex lectularius)*

This wingless bedbug, a notable blood-sucking parasite of humans throughout written history, has moved with us all over the world. The bedbug's adaptation to humans is so complete their bites are nearly painless. In the United States, bedbugs have been one of the most important pests. They were disliked more than cockroaches, but DDT so effectively controlled bedbugs in the late 1940s that they are of minor importance today.

Bedbugs are dark reddish brown, oval and very flat. Adults are almost $^1/_4$ inch long and become mature in about four weeks when host blood is available and temperature, humidity, and harborage are favorable. If hosts are scarce, bedbugs can survive for a year without feeding.

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. The surprise occurrence of bedbugs in urban homes often can be traced to these recreation facilities.

Eggs. Eggs are deposited several times each day in protected places near the host's sleeping area; several hundred might be deposited. Hatching occurs in one to two weeks, depending on temperature—the warmer the weather, the shorter the incubation time.

Nymphs. Nymphs, tiny and colorless at first, go through five molts, taking a blood meal between molts. This nymphal period can last from several weeks under favorable conditions to as long as a year when hosts are unavailable and temperatures are low.

Adults. Undergoing gradual metamorphosis, the bedbugs mate soon after becoming adults. Adult bedbugs prefer humans as hosts. Though they have been known to harbor several human diseases, ***there has been no record of disease transmission.***

Harborage

Under normal conditions, bedbugs feed at night. Flat bodies allow them to hide in cracks in beds, bedside furniture, dressers, wallboards, door and window frames, behind pictures, under loose wallpaper, and in rooms near host sleeping areas.

Figure 14.5. Bedbug, *Cimex lectularius.*

CONTROL AND MANAGEMENT OF BEDBUGS

Inspection

The bedroom is usually the center of infestation. All dark cracks and crevices are potential harborage.

- Inspect camping sleeping equipment.
- Inspect outdoor animal sheds and coops, even if not recently occupied.

Habitat Alteration

Because bedbugs have alternative hosts besides humans (e.g., rodents, some birds, etc.), excluding these animals is very important. Though it is difficult, infested woodland cabins must be vermin-proofed.

Inside

- Tighten, caulk, and screen routes of entry.
- Store mattresses in protected areas.
- To prevent mouse nesting, do not fold mattresses on cots when they are not in use.
- Open protective harborage inside, such as wall voids, or tighten it up completely.
- Open cabinets. This discourages rodent nesting.
- Make crawlspaces accessible to predators and light.

Outside

- Move woodpiles away from the structure.
- Keep weeds and shrubs away from the foundation.
- Eliminate garbage.

Pesticide Application

There is no tolerable number of bedbugs in occupied structures. Camps and hiking shelters should be treated only when there is evidence of an active bedbug infestation. Rodents found inside should be trapped or baited. Several general application pesticides labeled for bedbugs are available.

- Dust or spray desiccating dusts or labeled insecticides, etc.
- Use crack and crevice application methods to treat harborage thoroughly.
- Treat furniture joints.
- Ensure that treated tufted mattresses or depressed seams dry and are covered with bedding before they are used.
- Leave time for drift or droplets to settle before bedtime.
- Do not use space treatments or fogs. They are not effective.
- Check state regulations. Some laws allow the use of appropriately labeled residual pesticides for cracks and crevices. This reduces the need for repeated applications.

Follow-up

If treated infestations recur, evaluate to determine whether some harborage was missed or if the structure is being reinfested; revise the management plan. Monitor structures where periodic reinfestation occurs. Remember, camps used only seasonally should have a pest management plan too. Keep good records on pesticide use and application methods. Educate clients and maintain communication. Emphasize that bedbugs do not transmit diseases. Remove rodent baits when recreational buildings are occupied.

Two species of bedbugs can be found in bat colonies. Called **"bat bugs,"** these bugs are very similar in appearance to the common bedbug. They do not build up in structures as intensely as the common bedbug. Their host is the bat, but bat bugs wander when hosts leave during migrations. They are also disturbed by reconstruction and bat-proofing. An occasional bat bug appears in rooms usually just below attics. Locate infested bat nesting sites and dust after the bats and detritus have been removed.

Endangered Species

Be aware of endangered species of bats and other animals when treating bedbug infestations. Outside, treat rodent burrows only.

HUMAN LICE

There are three species of human lice: **head lice, body lice,** and **crab** or **pubic lice.** They all suck human blood and are not found on birds, dogs, cats, farm animals, or other hosts. The lice discussed here all belong to the insect order Anoplura.

Historically, the disease typhus, transmitted by body lice, was common where people were confined together and could not wash or delouse their clothing. This disease became epidemic within confined populations such as cities under siege or armies limited to trenches or on the move and unable to delouse their clothes. Typhus is a fatal disease and was so pervasive that it, more than wounds of war, determined who was victorious and who was defeated in wartime.

Widespread louse epidemics ceased being a problem when DDT dust became available during World War II. Although body lice became resistant to DDT when it was intensively and repeatedly used, other synthetic pesticides were found to work as well. Typhus epidemics are not caused by either head louse or crab louse infestations.

With the elimination of the large infestations, modern societies are puzzled and alarmed when small, persistent louse outbreaks occur. Common examples of small infestations are head louse infestations among elementary school-aged children, body louse infestations on people who are unable to care for themselves, and pubic louse infestations resulting from sexual intercourse with an infested partner.

Informed pest control technicians can be very helpful as consultants on louse infestations and can provide a great service by discouraging pesticidal use other than for hair treatment. Leaving directions on lousicide choices with parents, school medical personnel, physicians, or the infested individual strengthens the clients' confidence in the technician's technical understanding and discourages the application or spraying of pesticides.

HEAD LICE *(Pediculus capitus)*

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 children of elementary school age (only rarely on adolescents or adults). They scuttle about on the scalp between hairs with much more speed than might be expected of a small, soft, wingless insect with slender, hair-grasping claws on the ends of blunt legs.

Close adaptation locks head lice into the human scalp in several ways. First, louse claws grasp human hair so firmly that they do not fall or wander 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. Most importantly, head lice neatly glue their eggs (called nits) to the hair shaft, always within $^{1}/_{4}$ inch of the scalp. The tiny, pearl-like eggs stick alongside the hair so tightly that they can be dislodged only by being torn from the neat sleeve of biological glue by fingernails or a fine-toothed comb. Nits found farther than $^{1}/_{4}$ 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 or hats because they are so restricted to human hair and the scalp surface temperature of around 80 degrees F or a little more. Temperature preference and perhaps humidity are so critical that lice die at elevated temperatures and from excess perspiration. Conversely, at lower surface temperatures (about 50 degrees F), lice become torpid and do not move or feed. A reasonable speculation is that head louse nymphs hatch from nits on hair snatched by brushes and knit hats. The tiny nymphs then move toward the warmth of the next head covered by the cap or brushed by the brush. This normally limits ***transmission to siblings that have their hair brushed with a "family brush" or to children who use knit hats and brushes of friends.*** Louse infestations are often discovered by school teachers who are watching for the signs of itching heads, but classroom neighbors are not as likely to be infested as are brothers and sisters or close friends that sleep over and share brushes. Head lice have been shown by surveys in several large eastern cities to infest the heads of Caucasian and Oriental children but they very seldom infest those of black children.

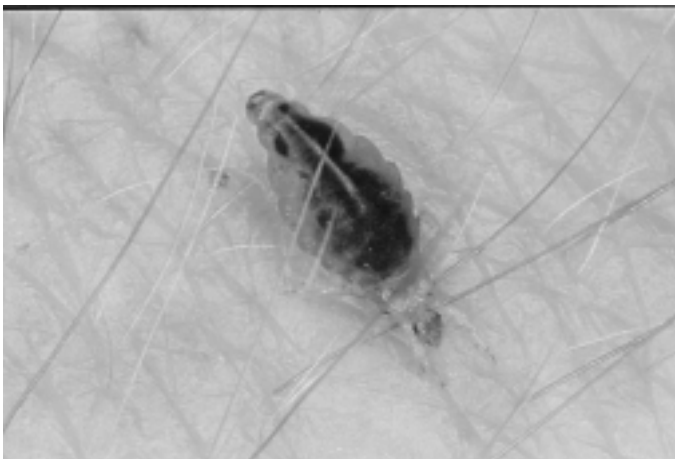


Figure 14.6. Head louse, *Pediculus capitus.*

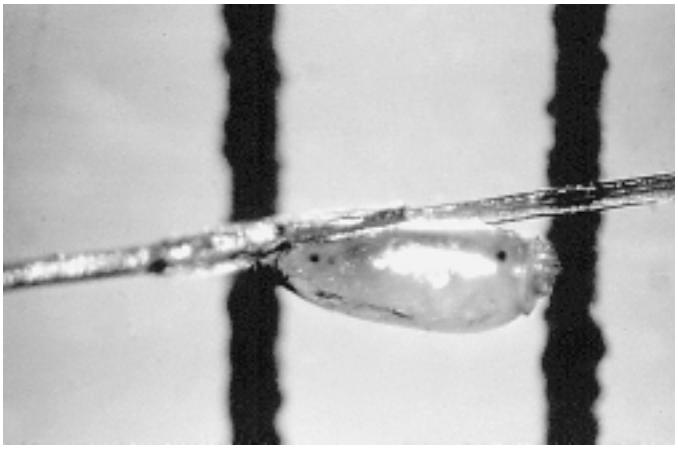


Figure 14.7. Head louse egg (nit).

Control of Head Lice

Several over-the-counter and prescription preparations 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 preparations from drugstores need to be used twice. 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 lousicides 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 knit 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.
- Clean rugs or simply quarantine them for 10 days after vacuuming.
- Remember, do not apply pesticides to rooms, toys, or furniture surfaces.

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

Reported louse infestations of adolescents and adults should be investigated by a physician. If live lice are not seen, the nits should be examined through a microscope to assure that they are not symptoms of scalp conditions.

BODY LICE *(Pediculus humanus)*

Head and body lice are indistinguishable in appearance and life cycle, but their behavior is very different. Both suck blood, but body lice engorge themselves, feeding to the point that their abdomens become purple and distended. Body lice are easily reared on rabbit blood after a period of assimilation but head lice can be successfully reared only on humans. Body lice harbor on clothes, hiding along seams and moving to the body to engorge. They do not deposit their eggs on body hair or head hair but on clothing. Body louse epidemics are controlled on humans by emergency applications of pesticides (dusts usually), but control is maintained by cleaning and washing clothes.

For these reasons body lice, historically the most common human louse, are now rare in the United States. Infestations appear on those who cannot take care of themselves, such as homeless individuals who do not remove clothes for cleaning and older, incapacitated individuals. Infested clothing passed from one individual to another is a common method of transmission.

Control of Body Lice

Some general application pesticide formulations are labeled for spraying but are of little value.

- Clean or wash clothing, bedding, etc., with hot water and detergents to kill lice.
- Bathe to detach and kill moving lice on the body.
- Use detergents and disinfectants to clean bed frames, bedside furniture, ambulances, and ambulance and hospital equipment.
- Counsel clients carefully to control emotionally charged situations and prevent louse reinfestations.

Figure 14.8. Head/body louse, *Pediculus* spp.

CRAB OR PUBIC LICE *(Phthirus pubis)*

Adult crab lice are only a little over half the size of body or head lice. Their last two pairs of legs terminate in hooked mitts that resemble crab claws. These lice are confined to coarse pubic hair and sometimes eyelashes. Pubic lice move very little in the pubic region and produce few eggs. The most common method of transmission is by sexual intercourse. When infested pubic hair detaches, lice can hatch on underwear, in beds, or on toilet fixtures. If their immediate environment is above 50 degrees F, a pair of pubic lice could infest another person.

Control of Pubic Lice

Accurate, calm communications are invaluable in explaining pubic louse infestations and making recommendations for their control.

- Use pubic louse preparations.
- Wash bedding and underwear.
- Use detergents or disinfectants in toilets.
- Vacuum.

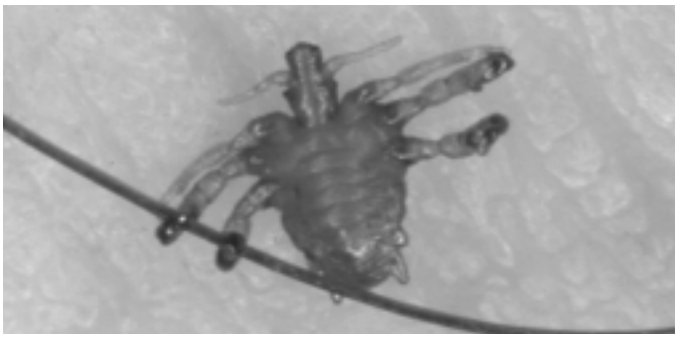


Figure 14.9. Crab louse, *Phthirus pubis.*

IMAGINARY PEST INFESTATIONS

Imagination is the ability to form a mental image to experience something that is not present. Everyone experiences an occasional itch that feels like crawling insects. A look confirms that either an insect is present or the mental image was not real. These unreal feelings can be troubling. Concern that the cause of an itch cannot be seen and may be a microscopic parasite can be overwhelming. This idea affects some people so strongly that it inhibits their ability to function. Imaginary insect-related problems can be separated into three groupings: entomophobia; contagious hysteria; and delusions of parasitism.

ENTOMOPHOBIA

Taken alone, entomophobia can be defined as an admitted fear of insects. This does not mean a fear of imaginary insects, but an exaggerated, illogical, unexplained fear of actual insects. A fear of insects occurs to a minor extent with a majority of people. In an extreme form, when the fear inhibits normal functioning, help from counseling professionals is needed. Group treatment has been found to be very successful.

Entomophobes rarely are problems for pest control technicians. However, their excessive desire for preventive pesticide applications may be encountered when clients attempt to coerce technicians to use pesticides unwisely. Such pressure should be resisted. Technicians should remain firm and apply controls only as professionally indicated by pest infestations. The term "entomophobia" is used sometimes generically to include all imaginary insect-related categories.

CONTAGIOUS HYSTERIA

As the name implies, imaginary pest infestations sometimes upset a group of people. This hysteria can be passed along or accepted by others. Contagious hysteria often occurs in an office workforce. Factors usually connected with the hysteria include:

- Crowded conditions.
- Overtime work.
- Excessively detailed or boring tasks.
- Changing climate.
- Changing seasons.
- Paper handling.
- Perceived unfairness of working conditions caused by physical arrangements in the workspace.

Classically, a few individuals, including a leader or spokesperson, begin feeling bites and discover rashes and other skin eruptions. These individuals identify certain portions of rooms where the pests are common and demand control. Supervisors usually do not believe there is a pest problem because they are usually unaffected by the contributing conditions, but they may be recruited as pressure for results mounts.

Inspection

- Look for pest infestations such as mites infesting stored products or populations of psocids and fruit flies that may cause entomophobia.
- Inspect for fiberglass filaments and for insect parts that could cause allergies.
- Do not allow obvious miscellaneous insects to become important for the sake of coming up with an answer.
- Carefully inspect the entire work area—the non-targeted part as well as the identified part.
- Listen to workers explaining their situation fully. Arrange for management not to refute or ridicule their statements. Not having a hearing entrenches feelings of unjust treatment. Ask if the pests are ever seen biting; ask to see the pests.
- Leave alcohol vials, tweezers, and a small brush so pests can be collected when seen later.
- Notice the differences between the pest-affected and non-affected parts of the workplace.

- Check air-conditioning, air filtering, workspace furniture, amount of window space, carpeting, type of work, proximity to duplicating equipment, and availability of refreshments, and compare the two areas. Where there is an apparent discrimination, bring it to the attention of the supervisors. Different conditions influence worker feelings.

Problems with contagious hysteria usually erupt during periods of seasonal change. Changing climate results in changing humidity and the need for the body to acclimatize to different atmospheric conditions.

- Notice static electricity around duplicating machines, and check the relative humidity of the office air. Low humidity dries skin and increases electrical static. This results in skin sensitivity, causes paper fibers to jump, and electricity discharges that snap and sting as well as cause hair to move on the skin, giving the impression of crawling insects.
- Periods of changing clothing styles—e.g., winter to spring, summer to fall—find people more restive. Changing climate and changes between heating and air cooling result in dry or humid air.

Habitat Alteration

Responses to the problem are needed. By the time responses are carried out, the condition often is rectified. Discuss observations with management. Suggest patience. Request physical changes in the environment.

- Inquire whether a physician has prescribed a pesticidal lotion. If this has happened, and it often does, strongly recommend that the lotion use be discontinued if no skin eruptions are seen, and substitute a non-pesticidal lotion.
- Inquire about the possibility of fiberglass insulation.
- Recommend that the workers at the center of the affected area be dispersed, that desks and furniture in that area be wiped down with disinfectants, and that intensive vacuuming or carpet cleaning be done. Leave the area empty for a time, if possible.
- Balance air cooling or heating. Bring relative humidity to 65 percent.

Pesticide Application

Unless there is real evidence of pest problems, NEVER apply pesticides. Do not make false statements relating to control of non-existent pests. Legitimate pesticide application in label-approved sites should produce clear results that can be seen. Otherwise, it will be viewed as a control failure and lost credibility will result.

Follow-up

Monitor the area periodically with sticky traps. Explain what the captured objects on the sticky surfaces are (e.g. small flies, dust, lint, cockroaches, etc.), and whether or not they are important. Identify any specimens or objects workers have collected in the alcohol vials. Use hand lens or microscopes, and let the workers view the specimens. After taking the steps outlined above, often simply demonstrating to clients that you are on the job and that you are competent and informed about pest management will be an adequate solution.

DELUSORY PARASITOSIS

A condition in which an individual has delusions of parasitism is an extremely emotional and sensitive situation. An inspection of the problem environment and an examination of specimens alleged to be the pest or parasites affirm or contradict the occurrence of an infestation to the technician but rarely to the client.

Often people affected by these delusions will have been referred from one or several physician(s) to a dermatologist, to a psychiatrist, to entomologists, to health departments, to pest control companies ad infinitum. The amount of time that must be expended by each consultant soon becomes excessive, and the patient experiences repeated rejections of one type or another—not to mention strain due to expenditure of time and money.

In any of these situations, it is possible that the complainant has a medically treatable condition. There have been cases in which drug abuse or conflicting drug prescriptions for patients being treated for several health problems elicited such manifestations. The fact is, there is little that can be done by anyone but a medical diagnostician with experience in the cause of delusions.

Always be honest in answering questions. Do not agree to see pests that are not there. NEVER apply pesticides in these situations. Remember, communicate with the client that only pest management technicians should apply pesticides only when active pest infestations have been identified and evaluated.

SUMMARY

The pests discussed in this chapter are not as commonly encountered as other pests found in or around structures. When infestations are found or suspected, however, they elicit fear—fear of being parasitized as well as a fear of the unknown. Calm, authoritative, and well communicated advice is very important for pest management technicians to use in situations involving biting pests.

SECTION 3
CHAPTER 14

Review Questions

Chapter 14: Ticks, Mites, Bedbugs, and Lice

Write the answers to the following questions and then check your answers with those in Appendix A in the back of this manual.

1. Ticks:
   A. Are the largest mites.
   B. Feed on the juices of plants.
   C. Adults have six legs.
   D. Feed on blood.
   E. A & D

2. Match the correct stage of tick development to each characteristic.
   A. Larva ____ Has six legs.
   B. Nymph ____ After feeding several days, drops off the host to lay eggs.
   C. Adult ____ After feeding several days, drops off the host to molt.
   ____ Referred to as "seed ticks."

3. Which is NOT true about ticks?
   A. Feeding attachment is often unnoticed by the host.
   B. May live for several months without feeding.
   C. Will try to crawl to the highest point on their host.
   D. Most ticks have only one host for each stage of development.
   E. Developing ticks usually find a larger host than they had during the previous stage.

4. Once a tick begins secreting saliva and feeding off of a host, it can detach itself easily.
   A. True
   B. False

5. Brown dog ticks may not feed for more than six months while they wait for a host.
   A. True
   B. False

6. Which tick(s) are responsible for the spread of Lyme disease?
   A. Deer tick
   B. Brown dog tick
   C. American dog tick
   D. Lone star tick
   E. C & D

7. Which tick(s) are responsible for the spread of RMSF?
   A. Deer tick
   B. Brown dog tick
   C. American dog tick
   D. Lone star tick
   E. C & D

8. Ninety percent of human Lyme disease cases are the result of feeding by nymphal ticks.
   A. True
   B. False

9-16. Match the following to the appropriate description:
   A. Deer tick
   B. Brown dog tick
   C. American dog tick
   D. Lone star tick

   _____ 9. Two-year life cycle; utilize three different hosts; adults the size of a sesame seed
   _____ 10. Complete life cycle in 3 months; lays up to 6,500 eggs in late summer
   _____ 11. All three stages will attack man
   _____ 12. There is an increased risk of humans contracting the disease they vector around large cattle and deer herds.
   _____ 13. Do not transmit disease to humans.
   _____ 14. Associated with white-footed mouse habitat; peak infection symptoms occur in July.
   _____ 15. Females are brown with a white spot in the center.
   _____ 16. Adults slightly over $^1/_8$ inch long are found on dogs and humans.

17. The critical time period for removing a tick before transmission of Lyme disease is:
   A. 10 to 12 hours.
   B. 24 hours.
   C. Three days.
   D. One week.

18. What advice would you give a client whose dog is infested with brown dog ticks?

19. What advice would you give a client who needs to remove a feeding tick?

20. List inspection procedures for disease-carrying tick populations.

21. List some pest management techniques for reducing disease-carrying tick populations.

22. How can permethrin-treated cotton balls placed in cardboard cylinders help reduce disease-carrying tick populations?

23. List some precautions for people who spend a lot of time outdoors to protect themselves from ticks.

24. Pesticides can be used in homes to control scabies mites.

    A. True

    B. False

25. A scabies mite found parasitizing a dog may also parasitize a human.

    A. True

    B. False

26. Burrowing by scabies mite females is noticed instantly by victims.

    A. True

    B. False

27-32. Match the following to the appropriate description:

    A. Scabies mites

    B. House dust mites

    C. Bird mites

    _____ 27. Lay eggs under the skin surface.

    _____ 28. Crack and crevice pesticide applications can be used to control.

    _____ 29. Cast skins and body parts may cause allergic reactions.

    _____ 30. Control by vacuuming intensely.

    _____ 31. Control by removing their hosts' habitat.

    _____ 32. Control by spraying carpet with tannic acid solutions.

33. Bedbug nymphs feed on the host's blood between molts.

    A. True

    B. False

34. Bedbugs are known to transmit diseases to humans.

    A. True

    B. False

35. List some pest management techniques for controlling bedbugs.

36. Typhus is transmitted by:

    A. Body lice.

    B. Bed bugs.

    C. Ticks.

    D. Crab lice.

    E. Head lice.

37. What procedures should be used when head lice are discovered in schools?

38-42. Match the following to the appropriate description:

A. Head lice
B. Crab lice
C. Body lice
D. All of the above

_____ 38. Wash bedding to control.
_____ 39. Deposit eggs on clothing.
_____ 40. Transmitted by sexual intercourse.
_____ 41. Found in coarse pubic hair and some times eyelashes.
_____ 42. Females lay about 100 eggs that hatch every 6 to 10 days.

43-46. Match the following to the appropriate description:

A. Entomophobia
B. Contagious hysteria
C. Delusory parasitosis

_____ 43. Imaginary pest infestation by an individual.
_____ 44. Exaggerated fear of real pests.
_____ 45. Imaginary pest infestation by a group of people.
_____ 46. Increasing relative humidity to 65 percent may help.

47. When investigating a possible case of contagious hysteria, you should:

A. Assure clients that their fears are not real.
B. Apply pesticides to calm fears.
C. Inspect for possible allergens.
D. Investigate problems with heating and air cooling.
E. C & D

SECTION 3

CHAPTER 15

MISCELLANEOUS INVADERS

LEARNING OBJECTIVES

After completely studying this chapter, you should be able to:

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

This chapter covers various arthropods that are occasional invaders of structures including **centipedes, millipedes, crickets, sowbugs** and **pillbugs, earwigs, western conifer-seed bugs, box elder bugs,** and **clover mites.** They are described as "miscellaneous" pests because they belong to different arthropod groups. Some of these pests can not be classified as insects. For example, centipedes and millipedes belong to two classes of the group

Myriopoda, and sowbugs and pillbugs belong to the class Crustacea. The other pests discussed belong to subgroups of the class Insecta.

When managing these pests, it is important to realize that their populations are often cyclic. They may be a problem inside buildings only during certain times of the year, or perhaps only a problem during certain years when populations are exceptionally high. The pest control technician should understand what environmental conditions lead to higher populations so that outbreaks of these pests can be anticipated. Very often habitat modification and exclusion methods are all that is needed to manage these pests successfully.

CENTIPEDES

Class Chilopoda

Centipedes are sometimes combined with millipedes in the large group Myriopoda. Centipedes are many-segmented arthropods with one pair of legs attached to each segment and somewhat long antennae. Except for one group, centipedes live outside under stones and logs.

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

Figure 15.1. Centipede, class Chilopoda.

House centipedes usually live in places that can be lightly dusted. If the area is damp, apply a light residual spray.

MILLIPEDES

Class Diplopoda

Millipedes are cylindrical, many-segmented arthropods with two pairs of legs attached to each segment. They have short antennae. Millipedes live outside in leaf litter. 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.

Figure 15.2. Millipede, class Diplopoda.

Habitat Alteration

- Remove leaf litter and compost near house foundations.
- Caulk around door and window facings.
- Weatherstrip doors and ground-level windows.

Pesticide Application

- 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 pesticide application around the house as a barrier.

CRICKETS

Family Gryllidae

Crickets are well known relatives of cockroaches 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.

FIELD CRICKETS

The most commonly seen crickets in the United States are field crickets. Adults are very dark and about 1 inch long. Eggs are laid toward the end of summer in moist soil of roadside ditches, meadows and fields, and along fences; in dry weather, they are laid in soil cracks, where adult crickets find some moisture for egg laying as well as for themselves. The female injects eggs into the soil by using a long, straight appendage called an ovipositor. The eggs overwinter and hatch in spring.

Crickets feed on plants and mature in July and August. When weeds begin to harden and die and rain is sparse, crickets often leave their ditches and fields. They move out in massive invasions. This is when they come into homes and buildings. Entry into structures is most always under doors and through open windows.

Field cricket populations are cyclical. Some years, great numbers find their way across parking lots and into malls and office buildings. Many years of low cricket populations may follow. Other crickets such as the house cricket, and the very small, dark brown *Nemobius,* also have cycles of buildup and movement into structures.

Figure 15.3. Field cricket, family Gryllidae.

CAMEL OR CAVE CRICKETS

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

Control and Management of Crickets

Inspection

- 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.

Habitat Alteration

- Caulk, tighten, and weatherstrip basement and ground-floor doors and windows to keep crickets out of houses.
- Thin plantings next to building foundations.
- Keep grass short during cricket activity to discourage the insects and reduce cover in case pesticide sprays are needed.
- Ventilate and remove materials that provide hiding places for cave crickets in crawl spaces and garages.

Pesticide Application

- Direct pesticide spray applications 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 swat field and cave crickets indoors or spray them with a general-use contact aerosol.
- Dusts on cave crickets in crawl spaces and garages may be used but are seldom needed.

SOWBUGS AND PILLBUGS

Class Crustacea

These small, oval land crustaceans, protected by objects on the ground, feed on decaying vegetable matter and fungi. They have been known to clip outside potted plant roots, but very little damage is expected of them. Heavy infestations outside encourage movement that causes individuals to find their way inside. Their generic names, *Porcellio* and *Armadillidum,* seem to distinguish these small oval arthropods.

Habitat Alterations

- Remove places where sowbugs and pillbugs can develop near the house, such as boards on the ground, flower pots, and flat stones.
- Remove mulch and replace with gravel, if necessary.

Figure 15.4. Pillbug, A*rmadillidum* spp.

Figure15.5. Sowbug, *Porcellio* spp.

EARWIGS

Order Dermaptera

Earwigs are conspicuous and easily recognized relatives of cockroaches. They are flattened insects with forceps or pinchers at the tail end. The forceps grasp insect prey. At first glance, earwigs appear to be wingless. In fact, their wings fold up many times under the small front wing covers. Some fly to lights. Earwigs feed on other insects and often scavenge in garbage and moist plant material. They also feed some on plant tissue, and at least one is a pest in greenhouses. They depend on high moisture. Earwigs are active at night. They shelter together and are quiet during the day.

Earwig females tend their young. They place their eggs in moist depressions or holes, guard them, groom them until they hatch, and take care of the early stage nymphs. Earwigs grow with gradual metamorphosis. Older nymphs and adults harbor together.

EUROPEAN EARWIG *(Forficula auricularia)*

The European earwig was introduced into the United States. This dark brown insect grows to be almost 1 inch long and is common in the Northeast, the Northwest, and

parts of southern Canada, and now is found in the middle Atlantic states.

Like most earwigs, the European earwig requires high moisture and builds up in shady yards where stones and boards offer protection. These earwigs enter on ground floors and can make their way into other parts of houses. They also hide in wrappings used to trap gypsy moth larvae.

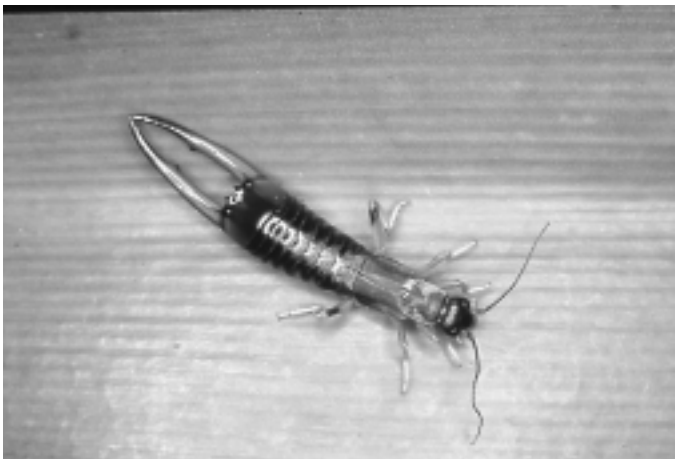


Figure 15.6. Earwig, *Forficula auricularia.*

Control and Management of Earwigs

Inspection

- Look under bark, boards, and stones near house foundations.
- Inspect cracks around foundation and door stoops.
- Check behind birdhouses, under tree trunk wrappings, and under plant mulch.

Habitat Alteration

- Caulk ground-floor entries, windows, and cracks between door stoops and patios and the building foundation.
- 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 buildup.

Pesticide Application

- Prepare a band of low-mowed grass on which residual pesticidal 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 quickly kill earwigs. Use pesticidal soaps labeled for this use.
- Dust in dry basement areas to kill earwigs there.

WESTERN CONIFER-SEED BUG *(Leptoglossus occidentalis)*

The western conifer-seed bug is a relatively new pest in Michigan. It has been migrating east over the last several years and its range is expanding rapidly. It is a conspicuous insect about $^{3}/_{4}$ inch long, with faint white stripes across the forewings. The hind legs are long and have leaf-like expansions (the family Coreidae, the leaf-footed bugs). When they fly, they buzz like bumblebees and expose orange and black stripes on their abdomens. They do not bite or sting.

Overwintered adults become active in late spring and feed on cones and flowers of pines. The females lay rows of eggs on needles of host pine trees. After hatching, the nymphs reach adulthood by late August, feed on ripening pine seed, and then look for overwintering sites. They frequently invade houses and other structures in late fall and early winter. Before entering, they often congregate on outside walls, especially those facing south, basking in the sun. Once inside, they may become active on warm days through winter and into spring.

Control and Management of Western Conifer-seed Bugs

Insecticides are not an effective control of western conifer-seed bugs indoors. Exclusion and habitat modifications are the best options:

- Install/replace weather stripping.
- Repair/replace screens.
- Caulk around windows, doors.
- Screen vents, chimneys.
- Repair soffits.
- Store firewood outside.
- Eliminate nearby host trees.
- Vacuum up bugs inside.

BOX ELDER BUG *(Leptocoris trivittatus)*

The eastern box elder bug *(Leptocoris trivittatus)* is a conspicuous black and red, undergoes gradual metamorphosis, and grows to be about $^{1}/_{2}$ inch long. It is distributed as far west as Nevada. These bugs lay eggs in the spring on female or pod-bearing box elder trees.

The young nymphs are bright red. Dark markings become more apparent on older nymphs. Nymphs feed on box elder tree foliage, tender twigs, and winged seeds. In late summer, mature nymphs and adults crawl down the tree trunk by the hundreds and disperse. Adults also fly directly from the tree to houses. Like attic flies, the bugs find spaces under siding, and around window and door facings, where they enter wall voids and rooms in houses

Box elder bugs seek overwintering shelter outdoors in tree hollows, as well as in sheds, barns, and houses. Those that find harborage indoors move around and fly on warm winter days.

Figure 15.7. Box elder bug, *Leptocoris trivittatus.*

Control and Management of Box Elder Bugs

Habitat Alteration

The best management method is to find female box elder trees and remove them. These trees are seldom planted as ornamental or shade trees. They grow as weed trees and are not eliminated mainly because they are difficult to identify.

Their leaves, somewhat like maples, are variably shaped on the same tree. Seeds are helpful in identifying the female trees. It usually takes a large invasion before tree removal is practiced.

- Caulk around entry points on the house foundation and door and window facings. At times it may be necessary to caulk obvious points of entry indoors.

Pesticide Application

- Spray tree trunks and foundations with microencapsulated pesticides when the migrating insects are noticed descending the tree or accumulating on the house sides.
- Vacuum bugs inside or spray with contact aerosols.
- Detergents have been shown to kill these bugs. Use pesticidal soaps labeled for this use.

CLOVER MITE *(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. Front legs, as long as the body, move like antennae. This characteristic distinguishes this mite from other red species.

There are no male clover mites in the United States. Females deposit their red eggs in bark crevices and building cracks during early summer and in the fall. Nymphs develop from summer eggs to invade dwellings in the fall. Eggs laid in the fall hatch the following spring.

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 their habitat optimum temperature reaches above 69 degrees F on sunny late fall and early spring days when general air temperatures are lower. As general air temperatures increase, the temperature in the mites' habitat grows too high. Both egg and mite development and activity suspend when temperatures exceed 75 degrees F or fall below 45 degrees F in their ground level habitat on grass or house foundations and siding.

When active, mites move from the grass area onto foundations, up under sheathing, or into wall cracks and spaces around windows that lead 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 and raking bare earth or, more often now, by hydro-seeding. Well fertilized grass contributes to the mites' well-being. Lack of shade allows uniform temperatures across the sunny lawns and buildings. Scraped, bare soil is devoid of predatory mites and insects. It encourages the free buildup of clover mites on new, fertilized grass. As the lawn matures and the plant, shrub, and tree community diversifies, a diversified insect population is supported and clover mite invasions essentially cease.

Control and Management of Clover Mites

Habitat Alterations

Whenever infested buildings and yards meet criteria that support clover mites, habitat alteration should be strongly recommended.

Outside

- Place bare earth covered with gravel, or gravel over plastic, as a barrier strip about 2 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 the spaces where window and door framing join building siding.

Inside

- Caulk window and door framing and weatherstrip windows on the sunny side of the house.
- Caulk electrical plates.

Pesticide Application

Outside

Use a pesticide labeled for mite control and other lawn pests. Thorough application of the pesticide is needed to reach the soil. Usually mite control is required only when invasions are underway. Placing the pesticides near the

building is an effective and immediate treatment, but treatment to the lawn at this time may be too late.

- Apply pesticide to the barrier area and the mowed grass adjacent to it unless mite activity is also obvious elsewhere.
- Place pesticides near the building being invaded. Sulphur is a possible miticide.
- Treat under sheathing, where possible, to kill mites that have accumulated there.

Inside

- Advise clients to place a thin film of cooking oil on windowsills to trap mites as a temporary control until pest management technicians arrive.
- Vacuum entering mites to immediately reduce the population. Use caution: sweeping or brushing can smear them.
- Use general-use spot treatment on surfaces where activity is very high. Mites will be killed on contact, and the residue will kill or repel mites for a short period following application.
- Use crack and crevice applications in structural joints and spaces from which mites emerge.
- Dust voids where mites have assembled.
- Emulsifiable concentrates, wettable powders, dusts, and pressurized canned pesticides labeled for mite control are effective.

Follow-up

Monitor lawns in new areas or subdivisions with actual or potentially high clover mite populations.

SUMMARY

Miscellaneous invaders are identified as such because they do not regularly occur inside or because their infestation is less serious to people or structures than those of other pests. However, species in this group are well known—and disliked. They frequently become newsworthy local topics. Their unscheduled, surprise occurrences are sporadic enough that people forget to guard against them and suddenly find themselves inundated. Clients often demand immediate action, leaving little time for thought and planning.

SECTION 3
CHAPTER 15

Review Questions

Chapter 15: Miscellaneous Invaders

Write the answers to the following questions and then check your answers with those in Appendix A in the back of this manual.

1-6. Match the following to the appropriate description:

A. Centipedes
B. Millipedes
C. Sowbugs and pillbugs
D. Earwigs
E. All of the above

_____ 1. Many-segmented arthropod, short antennae, two pairs of legs per segment.
_____ 2. Small, oval land crustaceans.
_____ 3. Control by removing habitat (leaf litter, stones, logs, etc.) near foundations.
_____ 4. Flattened insects with forceps or pinchers.
_____ 5. Many-segmented arthropod, long antennae, one pair of legs per segment.
_____ 6. Tighten up entrances (caulk, weatherstrip, etc.) to control.

7. A light pesticide dusting in basements is effective at controlling centipedes.

A. True
B. False

8. Which type of pesticide application(s) are recommended to control millipede infestations?

A. Residual crack and crevice around house foundations
B. Light dusting in basements
C. Aerosols/fogs
D. Barrier
E. A & D

9. To reduce habitat for sowbugs and pillbugs, use mulch instead of gravel as a ground cover.

A. True
B. False

10. What would you recommend a homeowner do to reduce earwig habitat?

A. Use mulch as a ground cover.
B. Trim hedges and plants away from foundation.
C. Dehumidify moist basements.
D. A & B
E. B & C

11. Which type of pesticide application(s) control earwigs?

A. Detergent sprays
B. Dusts in dry basements
C. Crack and crevice near foundations
D. A & C
E. All of the above

12-26. Match the following to appropriate description:

A. Crickets
B. Box elder bugs
C. Clover mites
D. Western conifer-seed bugs
E. All of the above

_____ 12. Increasing shrubbery and plant cover decreases population.
_____ 13. Males "sing" in the summer.
_____ 14. Lay eggs on a particular seed-bearing tree species.
_____ 15. $^{3}/_{4}$ inch long; faint white stripes on forewings; leaf-footed.
_____ 16. Buzz like bumblebees when they fly exposing orange and black stripes on their abdomens.
_____ 17. Deposit eggs at the end of summer in moist soil.
_____ 18. Small red insects, front legs as long as body.
_____ 19. Conspicuous black and red insect.
_____ 20. Lay eggs on pine needles.
_____ 21. A problem in buildings in late fall and early winter.
_____ 22. Smear red when crushed.
_____ 23. Control by caulking entry points.
_____ 24. Deposit red eggs in bark crevices and building cracks.
_____ 25. A problem in late summer when nymphs and adults disperse.
_____ 26. Cooking oil on windowsills will discourage entry.

27. The best way to control box elder bugs is to:
    A. Vacuum bugs inside.
    B. Remove box elder trees.
    C. Spray with contact aerosols.
    D. Caulk entry points.
    E. Use pesticidal soaps.

28. Which method(s) would be effective at controlling western conifer-seed bugs?
    A. Eliminate nearby host trees
    B. Residual crack and crevice
    C. Barrier application
    D. Exclusion (caulking, weather-stripping, etc.)
    E. A & D

29. Which method(s) are recommended for controlling crickets when populations are known to be high?
    A. Spray cricket habitat (fields, roadside ditches, etc.) in midsummer.
    B. Use dusts in crawl spaces.
    C. Use a residual barrier around buildings.
    D. Spray cricket habitat (fields, roadside ditches, etc.) in fall.
    E. A & C

30. Crickets are most likely to enter homes during wet weather.
    A. True
    B. False

31. To discourage infestation by clover mites:
    A. Use a 2-foot-wide gravel/plastic barrier on the shady side of buildings.
    B. Use a 2-foot-wide gravel/plastic barrier on the sunny side of buildings.
    C. Plant shrubs in front of the barrier.
    D. A & C
    E. B & C

32. Clover mites are a problem mainly in midsummer.
    A. True
    B. False

33. List some pesticide applications for controlling clover mites

SECTION 4

RODENTS AND OTHER VERTEBRATE PESTS

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

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

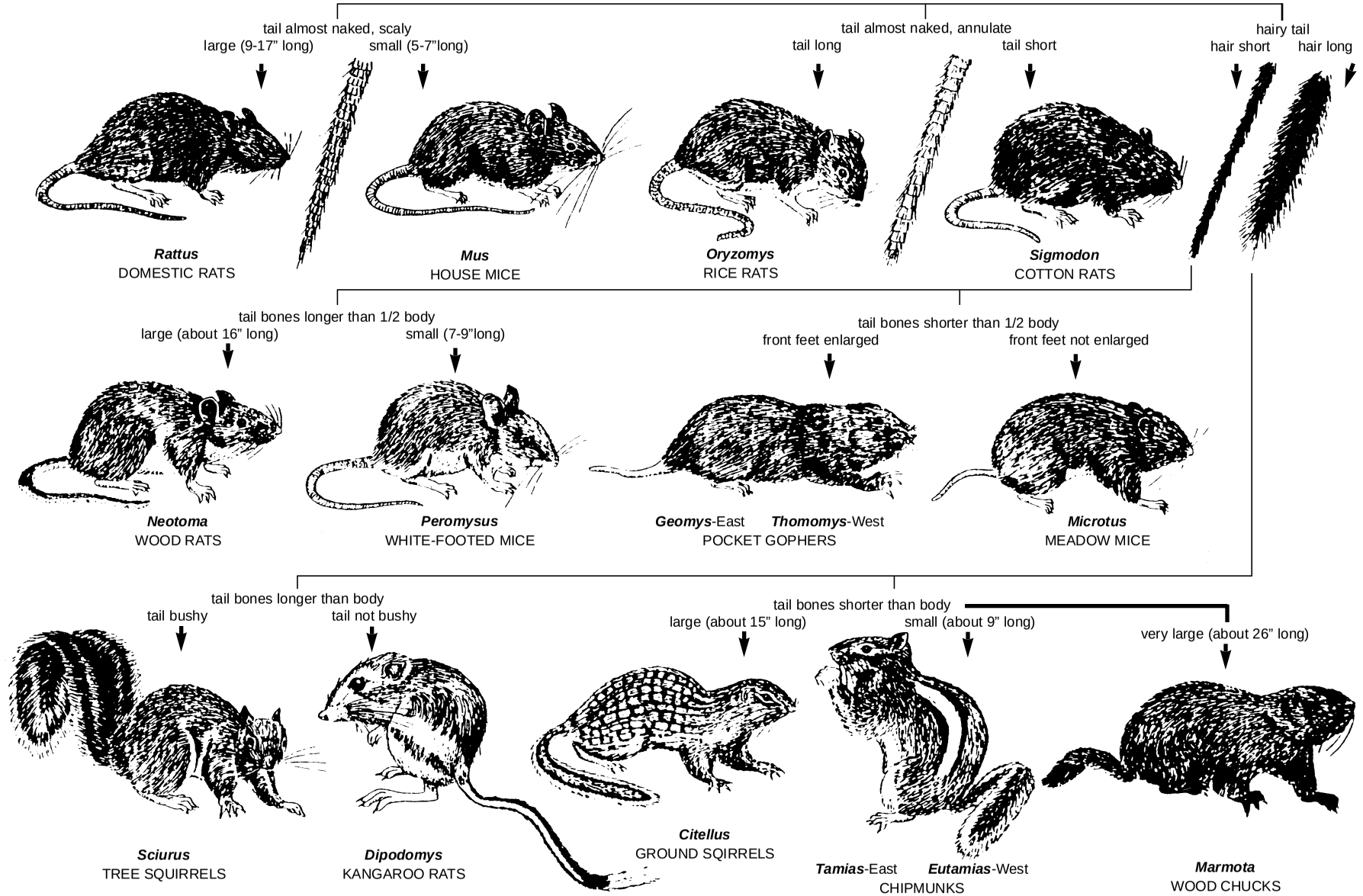
People feel a strong attachment to vertebrates that they do not feel toward other pests. Many people today are involved emotionally in protecting the welfare of animals, particularly vertebrates. Control of vertebrates other than rats and mice is more of a public relations problem than a pest problem. Killing is the control method of last resort.

Public concern for the welfare of animals and the risk to people, pets, and other non-targets from poisons used to kill vertebrates have made rules governing vertebrate pest control particularly strict. Laws and regulations at the state and local levels may be much more restrictive than federal regulations. Be sure you understand all the regulations that apply in your geographic area.

RODENTS

PICTORIAL KEY TO SOME COMMOM UNITED STATES GENERA

Harold George Scott, Ph.D.



1962, Department of Health, Education and Welfare, Public Health Service, Communicable Disease Center, Atlanta, Georgia

SECTION 4

CHAPTER 16

RATS

LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Know the appearance, habits, and habitats of rats.
- Be familiar with rat-spread diseases.
- Be able to describe monitoring procedures and tools used to inspect for rats.
- Be able to describe lethal and non-lethal methods of controlling rats.
- Know the various types of traps and baits used in rat control.

Rats have caused more human suffering and more economic damage than any other vertebrate pest. From causing plague epidemics (the "Black Death" of Europe) to rat-bite fever, whether feeding on stored grain or gnawing electric wires, rats are enemies of humankind. Statisticians estimate that rats destroy 20 percent of the world's food supply every year—directly by feeding and indirectly through contamination.

Yet rats' adaptability can be admired. They have adapted to most human environments. They live in granaries, in fields, in city sewers, on ocean-going ships, on roofs, in attics, in basements, in street trees, on top of 30-story buildings, and inside subway tunnels.

Adept athletes, rats can leap 3 feet straight up and 4 feet horizontally. They can scramble up the outside of a pipe 3 inches in diameter, and climb inside pipes 1 ½ to 4 inches in diameter. They can walk between buildings on telephone or power lines, and scramble on board a ship on its mooring line. Rats can swim a half-mile of open water, tread water for up to three days, swim against a strong current in a sewer line, and dive through a sewer trap to come up inside a toilet. They can fall more than 50 feet and survive.

Rats gnaw constantly. Their teeth are extremely hard. They commonly chew through building materials such as cinder block, aluminum siding, sun-dried adobe brick, wall board, 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 ½ inch high.

In most instances, rats are very wary. Hundreds may be nesting in a city block—in underground burrows, in sewers, on roofs, inside buildings—with few people in the area realizing it. 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, some 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 or feces. Sometimes they transmit disease indirectly—for example, when fleas first bite an infected rat, then a person. Below are some of the more important diseases associated with rats. These diseases often share similar symptoms, and medical professionals must perform the proper diagnoses.

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, feeding on a human, inoculates him/her with the bacteria that cause the disease. Although no major urban outbreak of plague has occurred since 1924, this is not a disease of the past. A reservoir of plague exists in some populations of wild rodents in several western states. Humans contacting these rodents could contract the disease. In the bubonic form of plague, symptoms include the sudden onset of fever with painful swelling of the lymph nodes. If the infection spreads to the lungs (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 and in 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, however, the disease organism enters the bloodstream when feces of infected fleas are scratched into a flea-bite wound. Symptoms may include fever, severe headache, and rash.

Rat-bite Fever

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

S*almonella* 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.

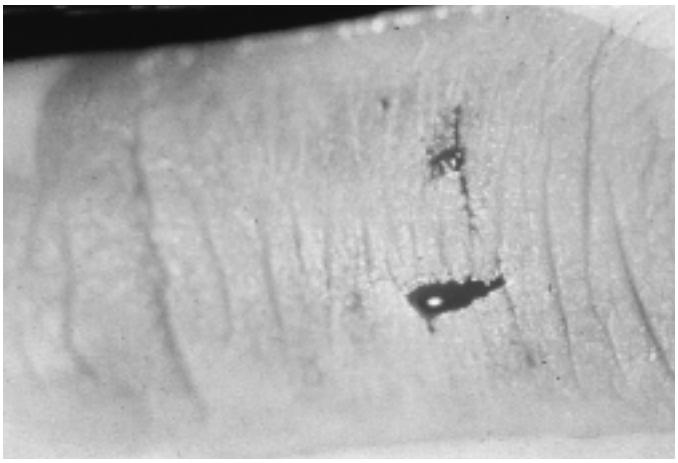


Figure 16.1. Rat bite.

Leptospirosis or Weil's disease

Human cases of this disease are seldom fatal. The disease organisms are spread from rat urine into water or food, and they enter humans through mucous membranes or minute cuts and abrasions of the skin. The disease may be so mild as to be unnoticed or may cause mild aches, pains, and fever. More serious cases, 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.

About Rabies

Rats in native habitats have not been found infected 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 most commonly found rat pest in Michigan is the Norway rat *(Rattus norvegicus)*. The Norway rat is also called brown rat, house rat, sewer rat, and wharf rat. The Norway rat is generally considered the most important rat in the United States. It is found in every state.

Figure 16.2. Norway rat, *Rattus norvegicus.*

HABITS OF RATS

Rats must be understood to be controlled. Knowledge of their life histories, habitat and food requirements, patterns of behavior, range, and other factors is essential to their management.

Life Cycle

A mature female rat can give birth to about 20 young in a year (four to six at a time), if she lives that long. The average life span of a rat in the field is less than one year; females live longer than males. The young are born in a nest. They are hairless, and their eyes and ears are closed. Within two weeks their eyes and ears open, they become furry and rat-like, and they begin exploring the nest area. In the third week, they begin to eat solid food, and imitate their mother to forage, escape, 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 experience can make control difficult in sites where long-term rodent control programs have been unsuccessful in the past. Young are totally weaned at 4- or 5-weeks old. They then weigh about 1½ ounces. At 3 months, the young are independent of their mother. They will mate and continue the cycle in the same location or will migrate to a new, unoccupied nest area.

Social Behavior

Rats are social animals and live in colonies with well defined territories that they mark with urine and glandular secretions. The 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 nest and resting sites and feed at their leisure. Weaker, subordinate rats 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, prime 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, and they react to shapes and movement rather than identifying objects by sight. The limit of their vision is 30 to 45 feet. Their eyes are adapted to dim light.

Other senses, however, compensate for poor vision. They use their sense of smell to locate food, follow pathways, tell whether 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 a parts-per-million concentration. This explains why rats often reject baits or avoid traps that have been contaminated with insecticides. Finally, rats have an excellent sense of balance that allows them to walk on wires and always land on their feet in a fall.

Fear of New Objects (Neophobia)

Rats are wary of anything new that appears in their territory. A bait station, a trap, a block of wood will be avoided for a few days until the rats become familiar with the new object; even then, they approach cautiously. This 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 doesn't 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. However, they will feed on non-preferred food if nothing else is available.

Rats often cache or hoard food in hidden areas. This food may or may not be eaten 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. Second, 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, but is usually around ½ 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, but short bursts of restlessness and activity can occur anytime, day or night. Rats commonly travel 100 to 150 feet from their nest 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

Outdoors, 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. Indoors, Norway rats nest inside walls, in the space between floors and ceilings, underneath equipment, between and under pallets, and in crawl spaces, storage rooms, and any cluttered area that is normally unoccupied. Norways prefer to nest in the lower floors of a building.

They also nest in sewers and 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.

Figure 16.3. Rat burrow.

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, 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 and 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 locations where rats rest or feed.

- Determine if a rat population is active by sweeping up old droppings, 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 glisten and look wet, and they have the consistency 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 that old droppings moistened by rain may look like new droppings; however, if crushed, they will crumble and do not feel like soft putty.

Figure 16.4. Rat droppings.

Urine

Both wet and dry urine stains will glow blue-white under an ultraviolet light (blacklight).

- Use portable ultraviolet lights developed by the food industry to identify rat urine on food items. Other substances besides rat urine also glow, so proper use of this inspection method takes practice.

Grease Marks

Oil and dirt rub off of a 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 and 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.

Figure 16.5. Rat droppings and grease marks.

Runways

Outdoors, rats constantly travel the same route. Their runways appear as beaten paths on the ground. Look next to walls, along fences, under bushes and buildings. Indoor runways (harder to identify) may appear as well polished trails, free of dust.

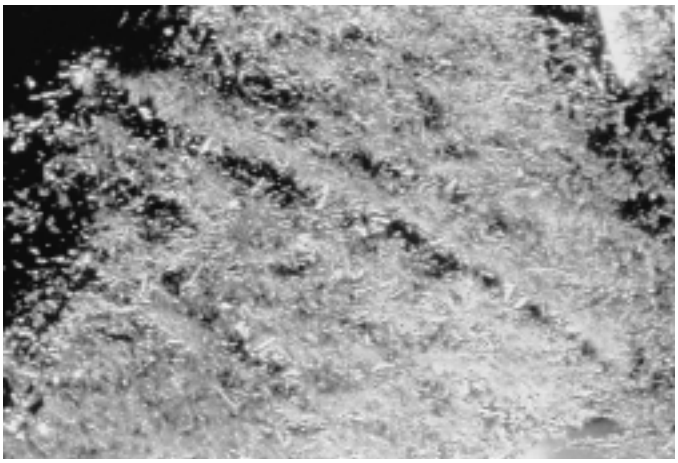


Figure 16.6. Rat runway in turf.

Tracks

A rat's foot print 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 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. Don't use flour, which 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, door corners, kitchen cabinets, and around pipes in floors and walls.

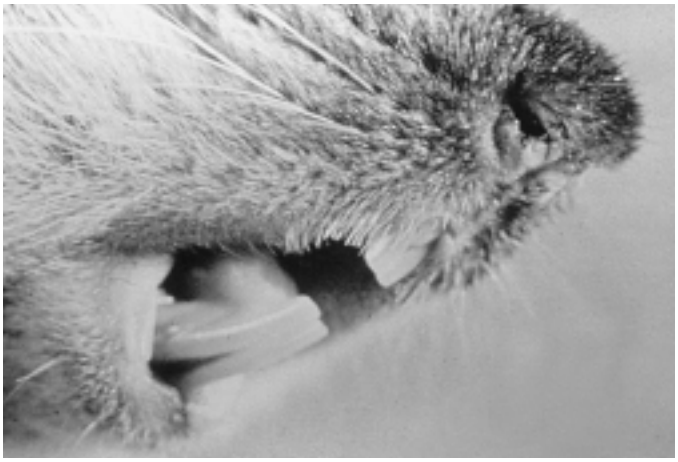


Figure 16.7. Rat teeth.

Figure 16.8. Rat gnawings on trash can.

Burrows

Outdoors, rat burrows may be found singly or in groups along foundation walls, under slabs and dumpster pads, in overgrown weedy 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.

Pet Excitement

Cats and dogs may excitedly probe an area of floor or wall where rats are present, especially if the rats have only recently invaded.

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 infestation, old droppings and gnawings can be observed. One or more rats are seen at night; no rats are seen during the day.
- When there is a high infestation, fresh droppings, tracks, and gnawings are common. Three or more rats are seen at night; rats may be seen in the daytime.

CONTROL AND MANAGEMENT OF RATS

Most successful rat control programs use a combination of tools and procedures to knock down the rat population and to keep it down. Methods used combine habitat alteration and pesticide application. Some of the tools, such as baiting and trapping, are lethal to the rat. Some tools are not—rat-proofing, for example. Sometimes applicators recommend changes that their customers need to make, such as increasing the frequency of garbage pickup or making building repairs.

The following sections describe some of the major techniques and tools used in controlling rats:

Sanitation

Food. Like all animals, rats need food to survive. Baiting programs often fail because the bait can't compete with the rats' regular food. The rats simply ignore the baits or cache them. Reducing the rats' normal food encourages them to feed on any rodenticide baits placed in their territory.

- Close or repair dumpsters and garbage containers that are left open or damaged.
- Clean up food spills.
- Do not allow food to be left out overnight.
- Outdoors, remove seeds spilled 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 side walls and placed so that aisles permit inspection and cleaning around the stored food.

Eliminate Hiding Places

Outdoors:

- 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.

Figure 16.9. Typical rat habitat.

Indoors:

- Reduce clutter in rarely used rooms—basements, storage rooms, equipment rooms.
- Organize storage areas.

Rat-proofing (Exclusion)

In the long term, the most successful form of rat control is to build them out. Also called rat-proofing, this approach 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.

Building Exterior:

- 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, especially between door and floor threshold.
- Fit windows and screens tightly.
- Caulk and close openings on upper floors and the roof, inspect under siding, and repair damaged soffits.
- Repair breaks in the foundation below ground level.

Figure 16.10. Rat entry point.

Building Interior:

- Seal spaces inside hollow block voids or behind wallboard. Repair broken blocks and holes around pipes.
- Repair gnaw holes or stuff them with copper wool.
- Equip floor drains with sturdy metal grates held firmly in place.

Traps

Snap Trap. The snap trap is an effective method of killing rats when used correctly. Trapping is advised for use in places where rodenticides are considered too risky or aren't working well, if the odor of dead rats in wall or ceiling voids would be unacceptable, or when there are only a few rats infesting a limited area.

Trapping has several advantages. There is less non-target risk from traps than from a toxicant. The technician knows instantly whether the trap has been successful. Traps also allow for disposal of the carcass so that there are no odor problems.

Careful attention to detail is necessary to ensure proper placement in adequate numbers or rats will simply pass them by.

The best traps are those with expanded triggers (treadles) set for a light touch.

- Leaving the traps baited but unset for a few days may increase the catch by reducing the chance that wary rats will trip the traps without capture.
- Set traps with bait, if food for rats is in short supply, or without bait if food is plentiful. Good baits for Norway rats include peanut butter, hot dog slices, bacon, or nutmeats.
- Tie movable bait to the trigger using string or dental floss, or the rat may simply remove the bait without triggering the trap.
- Sprinkle cereal, such as oatmeal, around traps to make them more attractive.
- Set unbaited traps along runways, along walls, behind objects, in dark corners where the rat is forced through a narrow opening. Place the trigger side of the trap next to the wall. (Rats will step on the trap during their regular travels.)
- When runways are located on rafters and pipes, set expanded trigger traps directly across them, fastening them to pipes with wire, heavy rubber bands, or hose clamps, and to rafters with nails.
- Set traps where droppings, gnawing damage, grease marks, and other evidence of activity are found.
- Use enough traps. A dozen may be needed for a house; a hundred for a small warehouse. Set five or ten traps in an active corner of a room. Set three traps in a row so a rat leaping over the first will be caught in the second or third. If unsure about sites of activity, set traps along possible runways spaced 10 to 20 feet apart.
- Camouflage traps when left with only a few rats that become very difficult to capture. Set traps in a shallow pan of meal, sawdust, or grain. (Place a small piece of cloth or plastic over the trigger to prevent the meal from jamming the mechanism.)
- In stubborn cases, expose food in shallow pans until the rats readily feed on it. Then add a buried trap.
- Move boxes and objects around to create narrow runways to the traps.
- Avoid spraying insecticide on the trap or even storing traps with application equipment. The odor of other rats improves a trap's effectiveness. Likewise, the odor of insecticide can make a rat steer clear.
- Inspect traps frequently to remove dead rodents and change old bait.

Glue Boards. Another way to trap rats is with glue boards. Glue boards use a sticky material that captures rodents. Although most often used against mice, they are sometimes effective against rats. Be sure to use larger glue boards that have been designed to trap an animal the size of a rat. Be aware that some people consider glue boards inhumane because the rodents are not killed instantly.

- Place glue boards in the same location as you would place snap traps. Place them lengthwise flush along the wall, box, or other object that edges a runway. Overhead runways along pipes, beams, rafters, and ledges are good sites too.
- Do not place glue boards directly over food products or food preparation areas.
- Secure the glue board with a nail or wire so a rat can't drag it away.
- Install glue boards in bait stations if people might be upset to observe a struggling rat, where children or pets could come in contact with the glue, or in areas with excessive dust or moisture.
- Check glue boards frequently and dispose of rodents humanely.
- Adding a dab of bait to the center of the glue board may improve its effectiveness.

Rodenticides

A rodenticide is a pesticide designed to kill rodents. There are three major formulations of rodenticides used to control rats: food baits, water baits, and tracking powders.

Food Baits. Rat baits combine a poison effective against rats with a food bait attractive to rats. At one time, applicators mixed their own baits. Now baits are mostly purchased ready-made and packaged as extruded pellets, in a dry meal, or molded into paraffin blocks for wet sites. Baits may be obtained in 45-pound bulk tubs, in "place packs" containing less than 1 ounce of bait, or anything in between.

Some baits kill rats after a single feeding; some require multiple feedings. Some are anticoagulants (causing rats to bleed to death), some affect respiration, and others have totally different modes of action. Some are only slightly toxic to people or pets, some are moderately toxic, and some are very toxic.

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.—stomach poisons that 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, however, recovered, became "bait-shy," and communicated their preference—or revulsion—to others in the colony. Because of this, these poisons were undependable.

A new type of rodenticide was developed in the 1940s that reduced the clotting ability of the blood. This material, warfarin, became the first anticoagulant rodenticide. Others followed: warfarin, coumafuryl, chlorophacinone, diphacinone, pindone, valone. The anticoagulants were effective and did not cause bait shyness. Several factors overcame the risks of acutely toxic poisons. Though the anticoagulants could be lethal to any warm-blooded animals, many species including poultry, farm animals, pets, and humans would have to consume large quantities over several days for fatalities to occur. Also an antidote, vitamin K, was developed.

Evidence of resistance to anticoagulants and a desire for quicker results drove the successful search for single-dose anticoagulants—brodifacoum and bromadiolone. In recent years, non-anticoagulant rodenticides with different modes of action, such as bromethalin or cholecalciferol, have been 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, which the 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.

Several general guidelines should be followed when using a poison bait. First and foremost, protect children, pets, wildlife, and domestic animals from eating the bait. All rodenticides have warnings on the label telling the applicator to place the bait "in locations not accessible to children, pets, wildlife, and domestic animals, or place in tamper-proof bait boxes." Evaluate each case to determine what are safe, inaccessible areas. Ask questions such as:

- Is it possible for a child to reach under a refrigerator to grab a place pack that you hid underneath?
- Could a guard dog at a warehouse find and eat the bait blocks you placed under a loading dock?

If so, change your placement or put the bait inside a tamper-proof bait box.

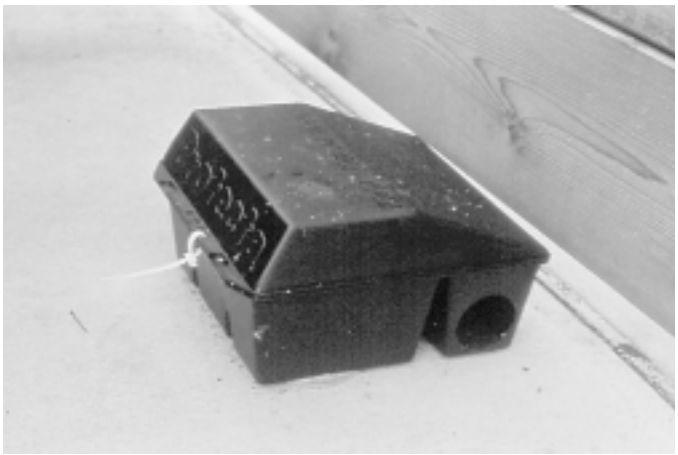


Figure 16.11. Tamper-proof plastic bait box.

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, but they are usually metal or heavy 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.

- 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 (near burrows, along walls, at other travel sites, etc.).
- 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 some time. The rats now consider it to be 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—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 and is swallowed when the rats groom themselves. The major advantage to 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 an 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 (when permitted by label). Apply with a hand bulb, bellows duster, or with a (properly labeled) flour sifter or salt shaker.

- Do not use tracking powders in suspended ceilings, around air ventilators, or near food or food preparation areas—the powder can become airborne and drift into 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.

SUMMARY

Rats have adapted to most human environments. Along the way, they have caused more human suffering and economic damage than any other vertebrate pest. But they are marvelous athletes and successful survivors as well. Successful long-term rat control is not simple. The key is to control rat populations, not individual rats. To be controlled they must be understood. Two of the most important biological factors to help control rats are their fear of new objects and their large foraging range of 100 to 150 feet or more from their nest.

Successful rat control programs usually use a combination of tools and procedures to knock down a rat population and keep it down. In the long term, the most successful form of rat control is to build them out, also called rat-proofing. Other control tactics include trapping and poisons. When using rodenticide baits and tracking powders, care must be taken to avoid risks to people, children, pets, and non-target animals.

SECTION 4
CHAPTER 16

Review Questions

Chapter 16: Rats

Write the answers to the following questions and then check your answers with those in Appendix A in the back of this manual.

1. A rat can compress its body and squeeze through an opening as small as:
   A. ¼ inch high.
   B. ½ inch high.
   C. 1 inch high.
   D. 2 inches high.

2. Rats are a major carrier of rabies.
   A. True
   B. False

3. There is no chance of a modern-day outbreak of plague in the United States.
   A. True
   B. False

4-9. Match the following to the appropriate description:
   A. Plague
   B. Rat-bite fever
   C. *Salmonella* food poisoning
   D. Leptospirosis
   E. Trichinosis
   F. Murine typhus fever

   _____ 4. Caused by a nematode spread by hogs eating food contaminated with rat droppings and humans subsequently eating undercooked pork.
   _____ 5. Bacteria transmitted by the Oriental rat flea.
   _____ 6. Disease organisms spread by rat urine in water or food.
   _____ 7. Bacteria causes mild flu-like symptoms but can be fatal, especially to infants.
   _____ 8. Disease organism enters bloodstream by scratching rat flea feces into fleabite wound.
   _____ 9. Bacteria from rat droppings in stored food or on dishes.

10. A mature female rat gives birth to about:
    A. 10 young/year.
    B. 20 young/year.
    C. 30 young/year.
    D. 40 young/year.

11. A reason for "bait shyness" in rats is:
    A. Young learn to be wary of baits from their mothers.
    B. Rats can taste chemicals at a parts-per-million concentration.
    C. Rats are wary of anything new in their territory.
    D. Other food sources are available.
    E. All of the above

12. Rats commonly travel a distance of _____from their nest looking for food and water and patrolling their territory.
    A. 10 to 25 feet
    B. 100 to 150 feet
    C. 1 to 2 miles
    D. None of the above

13. Which is NOT true of rat nests?
    A. Burrows have openings 2 to 4 inches in diameter.
    B. Burrows have "bolt holes" for emergency escapes.
    C. Indoors, Norway rats may nest inside walls, between floors and ceilings, under pallets and in crawl spaces.
    D. Indoors, Norway rats prefer to nest in attics.
    E. Norway rats will nest in sewers and storm drains.

14. When "hotel" nest sites are included in calculations, a rat's foraging range may be up to 20 acres.
    A. True
    B. False

15. Why is the hoarding behavior of rats a pest management concern?

16. Which of the following is NOT true about adult rat droppings?
    A. They average $^{5}/_{16}$ inch long.
    B. Fresh droppings are black or nearly black.
    C. The highest number of droppings will be found where rats rest or feed.
    D. A single rat can produce 50 droppings in a day.

17. In the, long term, the most successful form of rat control is rat-proofing ("building them out").
    A. True
    B. False

18. Match the inspection tool with the rat sign it is used to detect.
    A. Urine _____ Ultraviolet light
    B. Burrows _____ Light dusting of talc
    C. Tracks _____ Wadded-up newspaper
    D. Sounds _____ Stethoscope

19. With a medium-level rat infestation, you would NOT expect to see:
    A. Rats during the daytime.
    B. One or two rats at night.
    C. Gnawings.
    D. Droppings.

20. List some non-lethal methods used to control rats and give an example of each.

21. Rodenticides should be placed:
    A. In locations not accessible to children, pets, wildlife, and domestic animals.
    B. In tamper-proof bait boxes.
    C. Only outdoors.
    D. All of the above
    E. A or B

22. Some rat food baits may kill rats after a single feeding; others will kill after multiple feedings.
    A. True
    B. False

23. Clients should be made aware that rodent baits are only slightly toxic to humans.
    A. True
    B. False

24. When using a trigger trap to catch a Norway rat you should:
    A. Spray insecticide near the trap to keep insects away from bait.
    B. Set traps a distance away from droppings and gnawings.
    C. Bait with peanut butter.
    D. Place the trigger side away from the wall.
    E. C & D

25. Which type of baits are best placed inside rat burrows?
    A. Bait packs
    B. Bait boxes
    C. Water baits
    D. Tracking powders
    E. A & D

26. Once rats have fed from a bait box, remove it immediately.
    A. True
    B. False

27. When water is limiting, water baits can be used in open areas.
    A. True
    B. False

28. Tracking powder kills rats because:

    A. Rats swallow tracking powder when they groom their fur.

    B. Tracking powder is a powdery rodenticide bait.

    C. Tracking powder is absorbed dermally through the rats' skin.

    D. B and C

    E. None of the above

29. The advantage of using tracking powders is that they can be used anywhere.

    A. True

    B. False

30. The key to rat control is to control rat **populations,** not individual rats.

    A. True

    B. False

31. List some features of bait boxes that help make them "tamper-resistant."

SECTION 4

CHAPTER 17

HOUSE MICE

LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Know the appearance, habits, and habitats of mice.
- Be familiar with mouse-spread diseases.
- Be able to describe monitoring procedures and tools used to inspect for mice.
- Be able to describe lethal and non-lethal methods of controlling mice.
- Know the various types of traps and baits used in mice control.

The **house mouse** *(Mus musculus)* easily adapts to life with people. It thrives in a wide range of climatic conditions in a great variety of habitats, feeding on most human food and reproducing at a remarkable rate.

House mice are found throughout the United States and in most areas of human habitation. House mice are also found living in the wild, competing with native fauna. They are common inhabitants of grassy fields and cultivated grain crops. House mice have even been captured in open tundra in Alaska, miles away from human settlements.

Technicians will find that the house mouse is the most troublesome and economically important rodent. House mice are a common problem in homes and in all types of businesses. Nearly everyone can remember times when they were irritated by mice. Mice are nuisances to rich and poor alike. The continual drain that house mice impose on stored food and fiber, and the damage they cause to personal possessions are the most serious economic threats. House mice also have the potential to transmit diseases and parasites to people and domestic animals.

Control of house mice requires understanding mouse biology and habits, particularly the major differences between mice and rats. During the past few decades, control of rats has improved while problems with house mice have increased. Baiting programs often are more successful in controlling rats than they are in controlling mice.

LOSSES DUE TO MICE

When mice infest stored food, the greatest loss is not what mice eat, but what is thrown out because of real or suspected contamination. In six months, one pair of mice can eat about 4 pounds of food and deposit about 18,000 droppings. The amount of food contaminated by the mice is estimated to be about 10 times greater than the amount eaten.

So common are mice that the government permits a certain number of rodent hairs, and sometimes droppings, to remain in food commodities destined for human consumption (see Chapter 4). Yet food inspectors often have to condemn food products and fine manufacturers because of house mouse contamination in excess of that permitted.

Losses are not connected only with food. Family bibles or heirlooms stored in a trunk in the attic or garage that

are damaged by mice are irreplaceable, as are original paintings and manuscripts stored in museums. Mouse-riddled documents in the bottom file drawer of an office cannot generally be valued in dollars and cents, but these losses can be costly.

Electrical wiring gnawed by rodents has started many fires. Many fire-related incidents listed as "cause unknown" are probably rodentrelated. House mice frequently take up residence in electrical appliances and end up chewing into the power supply. This is particularly costly when computer systems are disrupted.

MICE AS DISEASE CARRIERS

Excluding the spread of food poisoning, house mice are not as important as rats as carriers of disease and parasites. Yet their potential cannot be overlooked. House mice and their parasites are implicated in the transmission of a number of diseases.

Salmonella Food Poisoning

Bacterial food poisoning, salmonellosis, can be spread when some foods are contaminated with infected rodent feces. Mice are probably more responsible than rats for the spread of this disease.

Rickettsial pox

Rickettsia akari is the causal agent of rickettsial pox, a disease causing a rash of the chicken pox type. Rickettsial pox is transmitted from mouse to mouse, then to people by the bite of the house mouse mite.

Meningitis

Lymphocytic choriomeningitis is a virus infection of house mice that may be transmitted to people (mainly to children) through contaminated food or dust.

Leptospirosis (Weil's Disease)

The mouse can be a major carrier of Leptospirosis (Weil's disease), although human cases are more commonly caused by rats.

Rat-Bite Fever, Ray Fungus, and Ringworm

Rat-bite fever can be transmitted by house mice. So can ray fungus, *Actinomyces muris.* Certain tapeworms are spread in house-mouse droppings, and 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 has been associated with house mouse infestations. The uncomfortable skin irritation and itching can affect children and adults. Mites may spread through all of a mouseinfested house or apartment during particular times of the year, and the dermatitis is frequently blamed on other causes (heat rash, allergies, fleas, and the like).

APPEARANCE

The house mouse is a delicate, agile little rodent. Adult weights vary from region to region and may be linked to the suitability of habitat, but they usually range from ½ to 1 ounce. Adult house mice vary in color from light brown to dark gray but most often are a dusky gray or medium brown over most of their bodies, except the belly, which may be a slightly lighter shade of their general color but never white.

Figure 17.1. House mouse, *Mus musculus.*

The mouse has moderately large ears for its body size. The tail is nearly hairless and about as long as the body and head combined (2½ to 4 inches). The feet are small in proportion to its body. The eyes are also relatively small (see Rodent Chart, page 152).

Our native deer (whitefooted) mice *(Peromyscus* spp.*)*, which often invade buildings adjacent to fields and woodlands, are about the same size as or slightly larger than house mice. Deer mice have a distinct, bicolored tail; the upper portion is brown or gray and the underside is distinctly white, with a welldefined line where the two colors meet.

Meadow mice or voles *(Microtus* spp.*)* sometimes invade homes. They are less agile, have larger, chunky bodies, and weigh at least twice as much as house mice. They also have much shorter tails and small ears and eyes.

HABITS OF HOUSE MICE

Life Cycle

Under optimum conditions, house mice breed year round. Outdoors, house mice may tend toward seasonal breeding, peaking in the spring and fall. Environmental conditions, such as the availability and quality of food,

can influence 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 densities, however, reproduction may nearly cease despite the presence of excess food and cover.

Newborn mice are quite undeveloped, weigh between 0.02 and 0.03 ounce and are nearly hairless. 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

Though mice are active primarily at night, some day activity occurs. Movements of house mice are largely determined by temperature, food, and hiding places. Home ranges of mice tend to be smallest where living conditions are good.

Mice tend to travel over their entire territory daily, investigating each change or new object that may be placed there. They are very aggressive. Unlike rats, they show no fear of new objects. They dart from place to place, covering the same route over and over again. This behavior can be used to advantage in control programs. Disturbing the environment at the beginning of a control program by moving boxes, shelves, pallets, and other objects can improve the effectiveness of traps, glue boards, and bait. Mice will investigate the changed territory thoroughly.

Senses of Mice

Like rats, mice have relatively poor vision and are color-blind. They rely heavily on smell, taste, touch and hearing. Mice use their keen sense of smell to locate food items and to recognize other individuals, especially those of the opposite sex. Taste perception in mice is good also. 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 the guard hairs on the body as tactile sensors to enable them to travel in the dark, pressing against walls and boxes, and scurrying through burrows.

Mice also have an excellent sense of balance. A mouse's ability to quickly carry out actions or movements is governed by a constant practice of sequences of muscular movements—sometimes referred to as the kinesthetic sense. The kinesthetic sense is a subconscious recording of a series of movements necessary to go from point A to point B. This activity occurs from stimulation of sensory nerve endings in muscles, tendons, and joints and allows mice to quickly escape danger.

Curiosity

Mice do not fear new objects as rats do. As mentioned earlier, they quickly detect new objects in their territory and investigate them. They will immediately enter bait stations and sample a new food (although they may only nibble on a small amount). They will also investigate traps and glue boards. Control programs against mice often have success early—just the opposite of rat programs.

Physical Abilities

It is difficult to mouse-proof a building or control mice without understanding their physical capabilities:

- For their size, they are excellent jumpers, with some of the more agile individuals jumping 12 inches (30.5 cm) 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 girders, 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 (6 mm) in diameter.
- They can easily travel for some distance hanging upside-down from $^{1}/_{4}$-inch (6 mm) 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 (2.5 meters) to the floor.
- They can survive at a constant 24 degrees F (30 degrees C) 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 more than other items, though they will feed on a wide variety of foods. Mice sometimes search for foods high in fat and protein, such as lard, butter, nuts, bacon, and meat. Sweets, including chocolate, are taken at times. Mice get much of their water from moisture in their food, but they will drink if water is readily 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, where mice will eat more than at other places. 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 as they get smaller.

Range

Mice are territorial and seldom travel more than 30 feet from their nest. Their range is much smaller than the rat's range of 100 to 150 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. Nests are constructed of fibrous, shredded materials such as paper, cloth, burlap, insulation, or cotton and generally look like a loosely woven ball. They are approximately 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 house 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.

INSPECTION

Sounds

Sounds are common at night where large numbers of mice are present.

- Listen for squeaks, scrambling, and sounds of gnawing.

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 *(Peromyscus* spp.*)* and meadow mice *(Microtus* spp.*),* 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 blacklight. Urine stains will fluoresce under ultraviolet light.

Grease Marks

Like rats, mice produce greasy smears where dirt and oil from their fur mark pipes and beams. House mouse spots are not as easy to detect.

- Expect markings to cover a smaller area than those made by rats.

Runways

Most house mouse runways are indistinct trails 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 16, Rats).

Gnawing Damage

Recently created gnawings on wood are light colored; 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 nestbuilding 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 of rats.

Estimating Numbers of Mice

Estimates are more difficult to get than for rats. The number of mice observed or food consumed is not highly reliable as a census technique with house mice. Unlike rats (which may travel widely within a building leaving tracks on many patches of dust), house mice do not range widely.

- Read natural signs such as droppings, urine stains, tracks, and damage.
- Make nontoxic tracking patches of talc at 20- to 30-foot intervals (5 to 10 meters) throughout a building. The more tracks seen in each patch, and the more patches showing tracks, the larger the population. The percentage of patches showing tracks will reflect the extent of the local infestation.
- Tracking patches are also an excellent means to evaluate a control operation. Compare the number of tracks or patches with mouse tracks before and after a control program.

CONTROL AND MANAGEMENT

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 exists, some kind of lethal control is necessary. Otherwise, the reproductive capability of the mice and their remarkable ability to find food in almost any habitat will keep their populations up or increase them.

House mouse control is different from rat control. Applicators who do not take these differences into account 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 bulk foods in mouse-proof containers or 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 materials away from walls and off of 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. This band and the areas around pallets should be swept often so that new droppings can be detected quickly.

Mouse-proofing

It isn't easy to completely mouse-proof a building because mice are reported to be able to squeeze through an opening as little as $\frac{1}{4}$ 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.

Traps

Snap Traps. If used correctly, snap traps are very effective in controlling mice. They must be set in the right places, in high numbers, and in the right position, or mice will miss them entirely. Here are some factors to keep in mind when trapping mice:

- Remember that the territory of mice rarely extends farther than 30 feet from the nest; more often about 10 feet. If mice are sighted throughout a building, it means that there are numerous discrete locations where you will have to set traps. Place snap traps not only wherever you see obvious signs of mice, but look for good trap locations in a three-dimensional sphere about 10 feet in diameter around those signs.
- Mice can be living above their main food supply in suspended ceilings, attics, inside vertical pipe runs, and on top of walk-in coolers. Or they can be below, in floor voids, crawl spaces, or under coolers and/or processing equipment.
- The best sites are those with large numbers of droppings—that means the mice are spending a lot of time there. Other good sites are along walls, behind objects, and in dark corners, particularly where runways narrow, funneling the mice into a limited area.
- Good mouse baits increase a trap's effectiveness. Peanut butter, bacon, cereal, and nuts are traditional, but one of the best baits is a cotton ball, which the female mice like to use for nest material. It must be tied securely to the trigger. Food baits must be fresh to be effective.

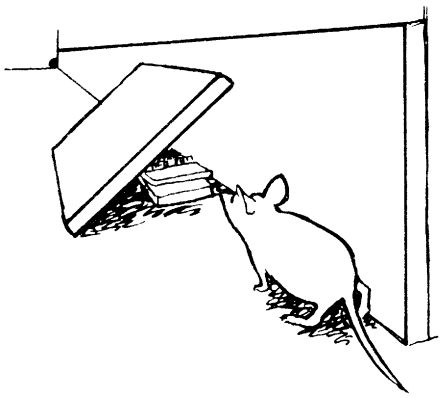


Figure 17.2. Place snap traps along walls and cover them with a board. This will force rodents to walk over the trap.

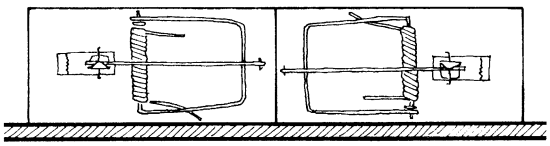


Figure 17.3. For greater effectiveness, place traps in pairs along walls to prevent rodents from jumping over a trap to avoid being caught.

- Probably the biggest mistake made in mouse trapping is not using enough traps. Use enough to make the trapping campaign short and effective.

Multiple-catch Traps. Multiple-catch mousetraps catch up to 15 mice without requiring resetting. Some brands are called "wind-up" traps; the wind-up mechanism kicks mice into the trap. Others use a treadle door. Live mice must be humanely killed.

Mice like to investigate new things. They enter the small entrance hole without hesitation. Odor plays a role too. Traps that smell "mousy" catch more mice. Place a small dab of peanut butter inside the tunnel entrance to improve the catch.

- Check traps frequently. Mice are captured alive but may die in a day or two. Some traps have a clear plastic end plate or lid so you can see if any have been captured.
- Place the traps directly against a wall or object with the opening parallel to the runway, or point the tunnel hole towards the wall, leaving 1 or 2 inches of space between the trap and the wall.
- If mice are active, place many traps 6 to 10 feet apart. For maintenance trapping, place the traps in high-risk areas and also at potential mouse entry points such as loading docks, near utility lines, and at doorways.

Glue Boards. Glue boards are very effective against mice. As with traps, placement is the key. Locations that are good trap sites are good sites for glue boards.

- Do not put glue boards directly above food products or in food preparation areas.

Figure 17.4. These multiple-catch traps will catch up to 15 mice and do not have to be reset each time one is caught.

- Set glue boards lengthwise and flush against a wall, box, or other object that edges a runway.
- Move objects around; create new, narrow runways 6 inches wide to increase the effectiveness of glue boards.
- Put peanut butter or a cotton ball in the center of the board.
- Place the glue boards 5 to 10 feet apart in infested areas; closer if the population is large.
- If no mice are captured in three days, move the boards to new locations.
- If a trapped mouse is alive, kill it before disposal. Replace the boards if they fill up with insects.

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 tamperproof bait boxes.

- Apply many small bait placements rather than a few large placements.
- Use baits labeled for mouse control.
- Place the baits in favorite feeding and resting sites, as revealed by large numbers of droppings.
- Place the baits between hiding places and food, up against a wall or other object to intercept the mice.
- Bait in three dimensions (see earlier discussion on trapping).
- Make bait placements 10 feet apart or closer in infested areas.
- If 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 locations 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 a water container. 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 a bait station, a PVC tube, a cardboard tube, or any small, dark shelter that a mouse could enter. Mice will explore such a shelter. Apply the tracking powder in a layer less than $^{1}/_{16}$ inch deep.
- Do not allow tracking powder to drift into nontarget areas.

SUMMARY

The house mouse is the most successful rodent in adapting to live with people. It is found almost anywhere people are, feeding on human food, sheltering in human structures, and reproducing at a remarkable rate. It is the most troublesome and economically important vertebrate pest, contaminating untold millions of dollars worth of food, damaging possessions, and causing electrical fires with its constant gnawing.

Many control failures against house mice are due to the applicator's lack of understanding of mouse biology and habits, particularly the major differences between mice and rats. Mice have a remarkable reproductive ability. A mated pair can produce 50 offspring in one year. They also have a foraging range much smaller than a rat's, usually only 10 to 30 feet. Baits, traps, glue boards, and the like must be placed close to the nest to be effective. Thus, good inspections are critical.

On the plus side, mice are curious and investigate new objects in their territory, so control measures can work fast when done correctly. Control of house mice is best when it is a three-part process: sanitation, mouse-proofing, and population reduction with traps and toxicants.

SECTION 4 CHAPTER 17

Review Questions

Chapter 17: Mice

Write the answers to the following questions and then check your answers with those in Appendix A in the back of this manual.

1. In 6 months, one pair of house mice can eat about 4 pounds of food and deposit about _____ droppings.
   A. 400
   B. 1,800
   C. 4,000
   D. 18,000

2. When mice infest food, the greatest loss is not what mice eat but what is thrown out because of contamination.
   A. True
   B. False

3. Government regulations currently exclude any contamination of food commodities by rodent hairs.
   A. True
   B. False

4. Mice are more likely to cause _____ than rats.
   A. Leptospirosis
   B. Trichinosis
   C. Rat-bite fever
   D. *Salmonella* food poisoning
   E. Plague

5. Mice, unlike rats, may also be responsible for the spread of:

   A. Leptospirosis.

   B. Meningitis.

   C. Trichinosis.

   D. Rickettsial pox.

   E. B & D

6-9. Match the following to the appropriate description:

   A. Dermatitis
   B. Meningitis
   C. Rickettsial pox
   D. Ringworm

   _____ 6. A rash caused by the bites of house mouse mites.

   _____ 7. A skin irritation caused by the bites of house mouse mites.

   _____ 8. A virus infection of house mice; transmitted to people through contaminated food or dust.

   _____ 9. A fungus, contracted directly or indirectly (through cats), from mice by humans.

10. Which is NOT true of mice's physical abilities?

   A. Can jump 12 inches from the floor onto an elevated flat surface.

   B. Are better swimmers than rats, diving below the surface.

   C. Can travel upside-down hanging off a $^1/_4$-inch hardware mesh.

   D. Can jump from a height of 8 feet to the floor.

   E. Can run up almost any vertical surface.

11. Voles (meadow mice) have shorter tails and smaller ears than house mice.

   A. True

   B. False

12. Mice, unlike rats, are shy of changes in their territory.

   A. True

   B. False

13. Which of the following is NOT true about mice?

   A. Outdoors, mice tend to breed all year long.

   B. Mice are mostly active at night.

   C. Females can produce up to 50 young per year.

   D. Mice seldom travel 30 feet from their nest.

   E. Mice are nibblers.

14. Mouse control is difficult because:

   A. They can squeeze through openings slightly larger than $^1/_4$ inch.

   B. There can be many nests in an infested building.

   C. They have a very high reproductive potential.

   D. All of the above

15. Which is NOT true of the food and water habits of mice?

   A. Feed at dusk and just before dawn

   B. May feed 20 or more times during an evening

   C. Prefer cereals over meats

   D. Must drink water every day

16. The signs of mice infestations can be differentiated from rat infestations by the:

   A. Size of gnawings.

   B. Odor.

   C. Urination pillars.

   D. A & C

   E. All of the above

17. The best way to estimate the number of mice infesting is by:

   A. The amount of food consumed.

   B. Nontoxic tracking patches.

   C. The number of mice observed.

   D. A & B

   E. All of the above

18. Mouse-proofing is all that is needed to control an existing mouse population.

   A. True

   B. False

19. Glue boards trap mice better than rats.

   A. True

   B. False

20. Which is NOT true about multiple-catch traps?

   A. Can catch up to 15 mice without requiring resetting.

   B. Mice often enter entrance holes without hesitation.

   C. Mice are killed instantly.

   D. Mousy-smelling traps often catch more mice.

   E. B & D

21. Tying a cotton ball to a trigger trap will attract mice.
    A. True
    B. False

22. The key difference between baiting mice and baiting rats is:
    A. You need to apply many small bait placements.
    B. You must use water baits.
    C. You need to wait weeks for mice to stop avoiding the "new" bait.
    D. Baits are not effective against mice.

23. Tracking powders should be applied in a layer less than $^{1}/_{16}$ inch deep for control of mice.
    A. True
    B. False

24. Tracking powders are more effective against rats than mice.
    A. True
    B. False

25. Mousetraps should be placed:
    A. About 6 inches away from a wall.
    B. Every 30 feet.
    C. Along walls, behind objects, and in dark corners.
    D. In the center.

26. Which would be an effective placement of glue boards?
    A. Every 5 to 10 feet in infested areas
    B. Lengthwise flush against the wall; along narrow runways
    C. Every 5 feet in food preparation areas
    D. In areas free of mouse droppings
    E. A & B

27. Why should you use food baits in three dimensions when controlling mice?

28. List some sanitation methods for controlling mouse populations.

29. List some ways to mouse-proof a building.

SECTION 4

CHAPTER 18

BIRDS

LEARNING OBJECTIVES

After completely studying this chapter, you should be able to:

- Identify the common types of "pest" birds.
- Describe the life cycles, habits, and habitats of common pest birds.
- Identify situations in which birds are considered pests.
- Describe the health hazards and property damage associated with bird pests.
- Discuss the chemical and non-chemical alternatives for bird control and management.
- Understand the legal considerations and know what precautions to take when managing bird pests.

Birds provide enjoyment and recreation while greatly enhancing the quality of life. These colorful components of natural ecosystems are studied, viewed, photographed, enjoyed, or hunted by most Americans. Bird watching as a sport and recreational activity involves more than 10 million people. For this reason, birds are strongly protected by laws, regulations, and public opinion.

Birds can become pests, however, when they feed on crops, create health hazards, roost in large numbers on buildings, contaminate food, or create a nuisance. No particular species can be flatly categorized as good or bad. Whether birds are beneficial or harmful depends on time, location, and activity.

PIGEONS

The domestic pigeon (*Columba livia)* developed from the rock doves of Europe and Asia and was introduced into the United States as a domestic bird. Rock doves originally nested in caves and holes, and under overhanging rocks on cliffs, so they comfortably adapted to window ledges, roofs, eaves, steeples, and other components of man-made structures.

Pigeons give pleasure to many people. Along with house sparrows, they may be the only "friendly" wildlife observed by many people living in an inner city. Many park visitors have adopted special pigeons that they feed every day. Pigeons are also bred for racing, stunt flying, and meat production. Pigeon racing is a sport in Europe and in some parts of the United States, with birds racing distances of 10 to 1,000 miles (the record is 3,000 miles).

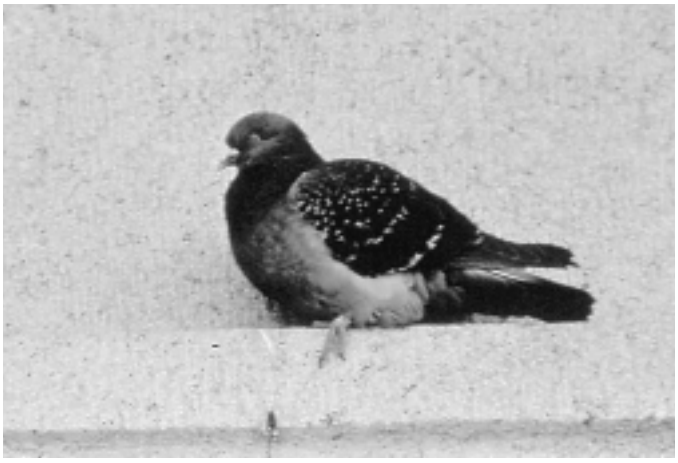


Figure 18.1. Pigeon, *Columbia livia*.

Pigeons are used for scientific research on heart disease in humans and diseases of domestic chickens. They are raised for food. The meat of pigeons, referred to as "squab," is considered a delicacy.

Pigeons have become the most serious bird pest associated with buildings. They may congregate in flocks of a hundred or more. Though primarily seed or grain eaters, pigeons in urban areas feed on garbage, spilled grains, insects, food left out by outdoor diners, and food provided by bird lovers, who intentionally feed pigeons bread, peanuts, and cookie crumbs.

Habits of Pigeons

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

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

Male pigeons are sexually mature at 3 to 4 months of age; females at 6 months. Pigeons usually mate for life unless separated by death or accident. If one partner of a mated pair is lost, the survivor will remate within a few days. After pairing and mating, nest construction begins.

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

One or two creamy-white eggs are laid 8 to 12 days after mating. Three or more eggs are sometimes found in a single nest, but this occurs when two or more hens share one nest. Both parents incubate the eggs for roughly 18 days—the male from midmorning through afternoon, and the female the rest of the day and evening.

At birth, the young pigeons are naked and helpless. They are fed "pigeon milk," a milkywhite fatty substance regurgitated from the parents' crops. After five days, the parents begin mixing grain and other foods with the pigeon milk, and after 10 days, they switch completely to whole grains.

During the first week or so, the young double in size daily and are full grown in less than a month. They are fledged when they are 37 days old. Average flight speed is 36 mph. Adult birds can mate again while the young are still in the nest.

Pigeons nest during all seasons when conditions permit. City pigeons generally remain in one area year round and produce 10 young per year. Nests that are continually used become solid with droppings, feathers, debris, and sometimes, dead birds.

Life span is highly variable, ranging from 3 to 15 years in urban roosts. Pigeons have lived for 30 years in captivity.

STARLINGS

European starlings *(Sturnis vulgaris)* were introduced into the United States in 1890, when 60 were brought to New York City. They rapidly expanded into new areas. Today, 140 million starlings range throughout North America.

Starlings are robin-sized birds that weigh about 3 ounces. Adults are dark with light speckles on their feathers in winter. The feathers turn glossy purplish black and green in summer. The bills of both sexes are yellow from January to June and dark at other times. Young birds are grayish.

Starlings have relatively short tails and appear somewhat chunky and humpbacked. The wings have a triangular shape when stretched out in flight. Starling flight is direct and swift, not rising and falling like the flight of many black birds.

Figure 18.2. European starling, ***Sturnis vulgaris.***

Habits of Starlings

Starlings nest in holes or cavities in trees or in rocks, or in urban areas on buildings, in birdhouses, on power stations and water towers, and in and on other structures. Starlings average two broods a year with four to seven young per brood. Both parents build the nest, incubate the eggs, and feed the young. The young birds leave the nest when they are about 3 weeks old.

Starlings migrate in some parts of the country. They begin forming larger flocks when temperatures become cooler in the fall. The major sources of food shift from insects and fruits to grains, seeds, livestock rations, and food in garbage. Roosting areas may shift from rural and

suburban areas into cities and towns. Each day, they may fly up to 30 miles to their feeding sites. Each starling eats about 1 ounce of food each day.

Leaving their evening roost at sunrise, they travel to feeding sites over well established flight lines. When they return to the roost just before sundown, they do not fly straight into their roost. They "stage" on high perches such as trees, power lines, bridges, and towers. The birds are quite social at these times and remain on pre-roost sites until after sunset, singing and calling to one another.

Starlings are pests because of their high numbers. Thousands or tens of thousands can roost at one site. Droppings at the roost site damage car finishes, tarnish buildings, drop on people below, and build up to such levels that they become a health hazard. Starlings have been responsible for outbreaks of a number of diseases.

When starlings roost in food processing plants or storage areas, they contaminate food. The birds consume large quantities of livestock feed and contaminate water at stockyards. The noise of a large flock can be irritating.

HOUSE SPARROWS

The house sparrow *(Passer domesticus)*, also called the English sparrow, was introduced into the United States in the 1850s. Populations now flourish all over the continental United States except in heavy forests, mountains, and deserts. It seems to prefer human-altered habitats in cities and around farm buildings and houses. In fact, though its still one of the most common birds, its numbers have fallen drastically since the 1920s when food and waste from horses furnished unlimited food.

The house sparrow is a brown, chunky bird 5 to 6 inches long. The male has a distinctive black bib, white cheeks, a chestnut mantle around a gray crown, and chestnut upper wing covers. The female and young birds have a gray breast, buffy eye stripe, and a streaked back.

Figure 18.3. Male house sparrow, *Passer domesticus*.

Habits of House Sparrows

House sparrows average three broods per season with four to seven eggs per brood. Breeding can occur in any month; through much of the country, it is most common from March through August. Eggs are incubated for about two weeks, and the young stay in the nest another two weeks.

The male usually selects the nest site. Nests are bulky and roofed over; they are located in trees and shrubs, on building ledges, in signs, on light fixtures, and under bridges. Nests often plug rain gutters or jam power transformers.

Sparrows are aggressive and social birds, often out competing native species. They have no recognized migration patterns and will stay in an area as long as food and nest sites are available. Young birds, however, move out of an area to establish new territories. Flocks of juvenile birds and non-breeding adults may sometimes travel 4 or 5 miles from nest sites to feeding areas. Sparrows are very tolerant of human activity and will not hesitate to set up housekeeping in high traffic areas.

House sparrows prefer to feed on grain. They will also feed on fruits, seeds, and garbage.

House sparrows can be pests in many situations. Their droppings contaminate stored grain and bulk food. Droppings and feathers can make hazardous, unsanitary, and smelly messes inside and outside of buildings, on sidewalks, and under roosting sites. Sparrows can also become pests when one or a few begin nesting inside a food plant, warehouse, mall, or atrium.

The birds cause damage by pecking at rigid foam insulation in buildings and nesting inside traffic lights. They create a fire hazard by nesting in transformers and power stations.

They are a factor in the transmission of a number of diseases, internal parasites, and external parasites (i.e., ectoparasites). Most significantly, they are thought to be a major reservoir of St. Louis encephalitis.

OTHER BIRDS

The three birds that most often become pests in the United States in urban areas are pigeons, starlings, and house sparrows. Other birds, from hawks to swallows, may occasionally cause unexpected and unusual pest problems. When blackbirds and crows roost in suburban areas they become pests. Woodpeckers peck holes into house siding looking for insects. Seagulls can feed at food plants.

Many of these birds are more protected by laws and regulations than the three birds discussed above. Special permits may be required to trap them or to control them by lethal means. The best approach emphasizes exclusion or modification of buildings.

HEALTH HAZARDS ASSOCIATED WITH BIRDS

Although health risks from birds are often exaggerated, large populations of roosting birds may present risks of disease to people nearby. The most serious health risks are from disease organisms growing in accumulations of bird

droppings, feathers, and debris under a roost. If conditions are right, particularly if roosts have been active for years, disease organisms can grow in these rich nutrients.

Birds may contaminate food, but this risk is usually limited to food manufacturing or processing plants. When parasite-infested birds leave roosts or nests to invade buildings, some of their parasites can bite, irritate, or infest people.

Histoplasmosis

This systemic fungal disease is transmitted to humans by airborne mold spores from soil contaminated by pigeon and starling droppings (as well as from the droppings of other birds and bats). The soil under a roost usually has to have been enriched by droppings for three years or more for the disease organism *(Histoplasma capsulatum)* to increase to significant levels. Although it is almost always associated with soil, the fungus, in rare instances, has been found in droppings alone, such as in an attic. Infection is by inhalation of the spores, which can be carried by wind, particularly after a roost has been disturbed.

Most infections are mild and produce either no symptoms or a minor flulike illness. The disease can, on occasion, lead to high fever, blood abnormalities, pneumonia, and even death. Based on histoplasmin skin tests given to large numbers of people throughout the United States, it is thought that about 50 million people have had histoplasmosis or been exposed to it. Each year there are about 500,000 infections, 5,000 people hospitalized, and 800 deaths in the United States due to histoplasmosis.

The National Eye Institute (NEI) at the National Institutes of Health has reported a potentially blinding eye condition, called ocular histoplasmosis syndrome (OHS), which results from infection by *Histoplasma capsulatum*. In this condition, the central part of the retina (the macula, used in straightahead vision) becomes inflamed and is damaged as blood vessels grow inside the affected area. NEI estimates that 4 percent of those exposed to the disease have tiny scars that put them at risk of developing OHS. An estimated 100,000 people have OHS in the rapidly progressive form that can lead to blindness.

Cryptococcosis

Pigeon droppings appear to be the most important source of the disease fungus *Cryptococcus neoformans* in the environment. The fungus is typically found in accumulations of droppings in attics, cupolas, ledges, water towers, and other roosting and nesting sites on structures. It has been found in as many as 84 percent of samples taken from old roosts. Even when old and dry, bird droppings can be a significant source of infection. As many as 50 million colony-forming units have been found in a gram of pigeon manure.

The disease is acquired by inhaling the organism's yeastlike vegetative cells (23 microns in diameter). There are two forms of cryptococcosis present in humans. The cutaneous form is characterized by acnelike skin eruptions or ulcers with nodules just under the skin. The generalized form begins with a lung infection and spreads to other areas of the body, particularly the central nervous system. It can be fatal. Like histoplasmosis, outbreaks of this disease often occur after building renovation, roost cleanup, or other actions that disturb old droppings.

Other diseases carried or transmitted by birds affect humans to a lesser degree. Psittacosis, pigeon ornithosis, and toxoplasmosis are normally mild in humans. However, serious illness or death can occur in rare cases. Pigeons and sparrows have also been implicated (along with many other species of birds) in outbreaks of encephalitis.

Ectoparasites

Pigeons, starlings, and house sparrows harbor external parasites that can invade buildings. Some of these parasites can bite and irritate. A long list of mites infest pigeons, but the northern fowl mite and the chicken mite are usually the main culprits invading buildings from nesting and roosting sites. Other pigeon ectoparasites that may cause problems inside buildings are the pigeon nest bug (a type of bedbug), various species of biting lice, the pigeon tick, and the pigeon fly.

Droppings, feathers, food, and dead birds under a roosting or loafing area can also breed flies, carpet beetles, and other insects that may become major problems in the immediate area. These pests may fly or walk into windows, ventilators, cracks and crevices, and the like and enter buildings.

Defacement and Damage to Structures and Equipment

Bird droppings under windowsills, "whitewashing" down a building face, or accumulating on sidewalks and steps are the most obvious problem associated with large roosts. Cleanup can be labor intensive and expensive, particularly on highrise buildings. Bird droppings are corrosive and will damage automobile finishes, many types of metal trim, electrical equipment, and machinery.

Figure 18.4. Defacement of building from pigeon droppings.

Droppings, nest materials, and feathers also block downspouts and vents on buildings. This accumulation of debris can attract insect pests such as carpet beetles and other dermestids, spider beetles, and mealworms.

Legal Considerations

With very few exceptions, all birds are protected by one or more federal laws and regulations.

- Pigeons, starlings, and house sparrows are not directly protected at the federal level but applications of toxicants or repellents must be made according to the product label and under the restrictions that apply under FIFRA.
- Other birds are regulated in some way at the federal level.
- Nontarget birds in the treatment area are protected, and any actions that kill or damage protected birds or their habitats will violate various federal and state regulations.
- State and local regulations may require permits or restrict actions that may be taken against these three pest birds.
- When in doubt, contact state and local natural resource agencies or the U.S. Fish and Wildlife Service District office in your area for further information.

TOOLS AND METHODS FOR MANAGING PEST BIRDS

Inspection

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

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

Habitat Modification

Habitat modification for birds means limiting a bird's food, water, or shelter. Attempting to limit the food or water of pigeons, starlings, and house sparrows is not practical. These birds will have a number of feeding and watering sites, often far from roosting and loafing sites. Where people are feeding birds in parks or lunch areas, education can help reduce this source of food; but in most cases, people will pay little attention to requests to stop.

The most successful kind of habitat modification is to exclude the birds from their roosting and loafing sites (addressed in the section on exclusion).

Pigeons may be induced to move from an infested site by the persistent destruction of nests and eggs. Nest destruction is ineffective against sparrows and starlings.

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

Exclusion

Some building designs and conditions lend themselves to bird infestation. Flat ledges, openings in water towers and vents, unscreened windows, and other attributes make a building an attractive location for roosting, nesting, and loafing. Modification or repair can exclude birds.

Typical solutions include replacing broken windows, adding screens, eliminating large crevices, and blocking openings into vents, cooling towers, and rooftop equipment with hardware cloth or similar material.

Exclusion methods also include the use of netting, custom-designed sheet metal or plastic covers, porcupine wire (Nixalite, for example), electrified wires, and sticky repellents to keep birds from roosting on ledges, roof edges, windowsills, building signs, and other surfaces favored by pest birds. Two advantages are that the birds are not killed and the control is comparatively longlasting.

Netting. Netting is used to block access of birds to large roosting areas in structures. Netting is especially useful in warehouses and around mechanical equipment areas where aesthetics are of minor consideration. It has been used successfully on cooling towers. Plastic nets have replaced metal and fiber nets in bird control. Plastic nets are normally extruded black polypropylene and are made with an ultraviolet inhibitor to reduce UV degradation. Knotted nets are also available. Nets will last from 2 to 5 years, depending on exposure to sunlight.

Covers or Ramps. Custom-designed covers for ledges, window air-conditioning units, and roof edges are the best technical solution to keep birds from infesting these sites. The high cost of this method usually eliminates this option on large buildings that have extensive roosting sites. But covers are valid options where limited applications will keep birds off selected sites, and where aesthetics are an important consideration. The covers usually consist of sheet metal installed at a 45 degree angle to prevent the birds from landing. Sometimes plastic inserts are customfit into the indentations to block off ledges.

Spikes. Porcupine wire, sharp metal spikes, or any similar "bed of nails" can stop birds from roosting on ledges. Where they can be used, they usually work fairly well. If aesthetics are important, these devices are usually limited to areas where they cannot be easily seen.

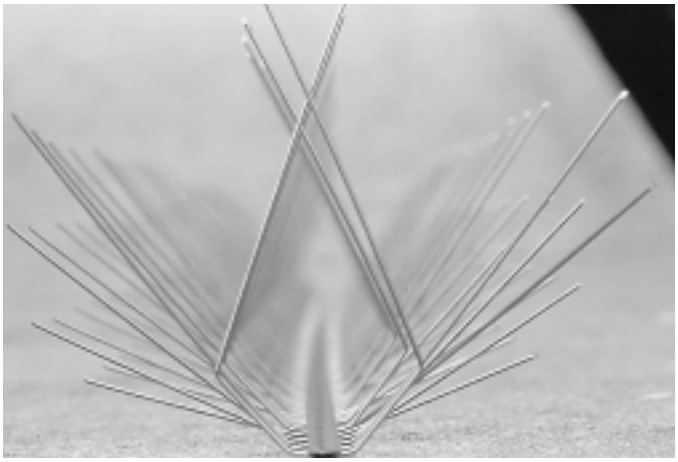


Figure 18.5. Nixalite (porcupine wire).

- If pigeons are likely to drop nest material and other debris on top of the newly installed spikes in an attempt to create a new roosting surface, install metal spikes on potential landing sites above the installation.
- Check metal spikes every six months for accumulated debris or nest material. Advise clients to regularly remove falling autumn leaves and other matter that can cover the spikes and reduce their effectiveness. Ensure that no tree branches hang over protected ledges.

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

- Before applying sticky repellents, clean ledges that are covered by bird droppings, feathers, and nest material with a wire brush, paint scraper, high-pressure hose, or by steam cleaning.
- Ensure that surfaces are clean and dry.
- Seal concrete, unpainted wood, or brownstone with silicone or other sealant, paint, or shellac before applying repellent. Sticky repellents will be absorbed into porous materials.
- Use a caulking gun to apply repellent. The depth of the bead necessary to repel various species of pest birds is roughly as follows: crows and sea gulls, $\frac{3}{8}$ inch; pigeons, $\frac{1}{4}$ inch; starlings, $\frac{1}{8}$ inch; sparrows, $\frac{1}{16}$ inch. The pattern of application will depend on the site and personal preference. The caulking gun should be held at an angle of 30 to 45 degrees.
- Apply a straight bead on ledges and roof edges $\frac{1}{2}$ inch from the outer edge, with another bead 3 inches in from the first. They can also be applied in a zigzag or "s" curve.
- For another option, combine a straight line $\frac{1}{2}$ inch from the outer edge and an "s" curve 3 to 5 inches back.
- Place breaks in the bead every few feet to avoid trapping rainwater against the building.
- For easy removal and replacement, apply waterproof sticky repellent tape on ledge and roof edges.
- Apply bulk gels with a paint roller, putty knife, or bulk caulking gun.
- Apply liquids with a roller, brush, or compressedair sprayer to girders, rods, sign supports, and rooftops. They can also be used to treat the upper surfaces of branches in trees and bushes. The repellent should be $\frac{1}{16}$ to $\frac{1}{8}$ inch thick. Liquid application is not recommended for sites where the appearance of the sticky repellent would be undesirable.

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

Certain precautions should be followed when sticky repellents are used:

- Remove nests.
- Check state and local regulations that may prohibit destroying or disturbing nests containing eggs or young.

Under some conditions, sticky repellents stain the surfaces to which they are applied. Some products melt and run when exposed to direct sun and high temperatures.

- Review labels and the manufacturers' technical information on the effective temperature ranges of various products.
- Compare the stability of various products by running a test on a sunny roof or window ledge.

Birds occasionally get stuck in sticky repellents. When this happens, their feathers will get gummed up and they'll be unable to fly. If a bird becomes gummed up with repellent, it can sometimes be rescued by cleaning the flight feathers with a small amount of mineral spirits followed by mineral oil. In most cases, cartridge applications (as described earlier) will repel the birds with little risk of entanglement.

Ultrasonic Devices

It should be noted that numerous tests by university, government, and private independent researchers have failed to demonstrate any efficacy against birds by any of the ultrasonic devices tested. ***These devices do not work against birds.***

Trapping

In many instances, trapping can be an effective supplemental control measure. Trapping is especially effective against pigeons. Where a group of birds is roosting or feeding in a confined and isolated area, trapping should be considered the primary control tactic.

The best time to trap pigeons is in the winter, when their food is at a minimum. There are many pigeon traps to choose from; which type and size are best is debatable. Most pigeon trapping programs use large walk-in traps. These can be 4 to 6 feet high and designed to be disassembled and moved. Another common type is a low-profile bob trap that is about 8 inches to 2 feet high. The door or entrance through which pigeons are lured is the principal feature of a trap.

- Set traps in inconspicuous places where pigeons commonly roost or feed and where traps are not likely to be vandalized (a major risk in trapping programs). Trap placement is important, and moving an inactive trap just 10 to 15 feet may significantly improve catches.

Feeding areas are the best trap sites, but they are rarely on the same property as the roosting sites. Rooftops that have water from cooling towers or air-conditioning units are often good trapping sites in summer.

The most difficult part of trapping is motivating birds to feed in a non-feeding area so that they will follow the bait into the trap. Whole corn or sorghum are generally the best baits but wheat, milo, oat groats, millet, popcorn, sunflower seeds, peas, greens, bread, or peanuts can be very effective if the birds are feeding on similar food. Once a few birds have been trapped, putting a variety of foods in with the birds can show which bait they prefer.

- In the first few weeks of a program, scatter small quantities of bait throughout the area to start the birds feeding and determine the best trap sites. Some specialists leave traps propped open for the first few days to allow the birds to get used to them.
- When the birds are calmly entering the trap, set it. Put bait and water (a "chick fount" is ideal) inside the trap and just a handful or so outside the trap. Leave one or two "decoy" birds in the trap to draw in other birds. Light-colored birds make better decoys than drab ones.
- Remove trapped birds regularly (except for decoys) otherwise, other pigeons will be frightened by fluttering trapped pigeons in the trap. Since pigeons can fly great distances and find their way home, trap and release is not normally effective. In most cases, trapped birds should be humanely destroyed. Some experts recommend gassing with calcium cyanide, but many feel it is simpler and more humane to kill the bird by breaking its neck.

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

Sparrow traps come in various sizes and shapes. The sparrow funnel trap is a double funnel that prevents sparrows from escaping after they have traveled through two funnels going for food bait. Fine cracked corn, millet, wheat, or bread crumbs make good bait. Trap sites should be baited for a few days before you actually begin trapping. Sparrow traps are usually more effective when placed on the ground. Nest box traps attract a sparrow with a potential nest site. Once inside, the bird trips the mechanism, which dumps the bird into a collecting bag. This trap also works against starlings, as does the center drop trap. The birds, attracted by food, drop through an opening and cannot escape. However, starlings are not usually good candidates for trapping programs.

LETHAL ALTERNATIVES

Avitrol

Avitrol is a poison bait with flockalarming properties used to control many kinds of birds. There are different Avitrol baits for each pest bird species—whole corn for pigeons, smaller grains for sparrows and other birds. Within 15 minutes of eating a toxic dose of Avitrol, birds flutter erratically and go into convulsions. They may fly away from the baiting site, they may fly into windows, or they may "dive bomb" into the ground.

Affected birds convulse for an hour or more. Most die within a few hours, but some last for as long as 15 hours. Only a small percentage of the flock (usually from 5 to 15 percent) needs to be affected for an Avitrol program to be

successful. The flock becomes frightened by the convulsions and distress of the poisoned birds, and anywhere from 65 to 85 percent of the flock will leave the area.

Prebaiting

At most sites, birds must be trained to feed on bait. Though baits are different for each bird, the general process is the same. Here is the procedure for pigeons:

- Place untreated whole corn in numerous piles on flat rooftops, ledges, and similar sites in the treatment area.
- Place many small piles (¼ pound each) 20 feet apart.
- Place about twenty ¼ pound piles of bait on a flat 5,000-square-foot roof.

The goal in prebaiting is to get at least 40 percent of the birds to accept the untreated bait. Expect the effort to take from three days to three weeks. When possible, remove all untreated prebait corn before switching over to Avitrol.

Cardinals, blue jays, doves and certain other seedeating birds also eat whole corn. Do not use Avitrol where non-target birds fed on the prebait unless the site is one of many. When this happens, continue baiting the isolated site with untreated corn. In this way, non-targets will be kept away from your Avitrol baiting sites.

Avitrol whole corn is not used alone—it is mixed with untreated corn in ratios ranging from 1 part Avitrol and 29 parts untreated bait, up to the maximum ratio of 1 to 9. The higher the proportion of Avitrol, the better the chance to move the flock quickly. However, this also increases the number and visibility of dead or convulsing birds.

With good bait acceptance, a ratio of 1:29 (treated:untreated) will generally kill about 5 percent of the flock; a 1:9 blend will generally kill 15 percent or more.

- Use the ratio that best fits the job.
- Keep in mind that you're trying to relocate the flock, not kill every pigeon.

The amount of Avitrol bait set out should be about half the total prebait used each day. For example, if 8 pounds of prebait have been set out each day for a flock of about 100 birds, 4 pounds of the Avitrol blended bait should be set out when you switch over.

One Avitrol application is adequate for most jobs. At large commercial operations (e.g., a freight yard), bait may need to be placed daily for a few days. If pigeons become bait-shy, wait about 3 weeks, then begin a new prebaiting program. If a site has been getting monthly Avitrol "maintenance" baiting, pigeons can become extremely bait-shy. Prebaiting for as long as 3 or 4 months may be necessary, so it is usually best to switch to another control method.

Use care to follow directions for using Avitrol specifically for each species of pest bird. Read the label carefully.

Secondary poisoning, in its classical definition, is not a risk with Avitrol because the chemical is metabolically changed in the tissue of affected birds. However, if a dead or dying bird has a supply of Avitrol-treated bait in its crop, there is potential risk to an animal feeding on this bird.

Toxic Perches

A toxic perch is a metal container with a wick surface that holds a liquid contact poison that birds absorb through their feet when they stand on the perch. The toxicant (fenthion) is hazardous to all birds and animals **including humans.** Toxic perches are particularly useful where food is in constant supply or Avitrol bait is not accepted. They are applied in locations where birds will perch on them, usually in the evening hours. An average-sized job will require 10 to 12 perches; a large job might require 30.

Toxic perches can be used only in certain sites: inside buildings and structures (non-food areas), on building tops, structural steel, power plants, or substations, and at feedlots, loading docks, and storage yards. Pigeons develop a site-specific aversion to perches placed at feeding, loafing, or watering sites but not usually in roosting sites. Perches usually need refilling twice per year. In hot weather, perches sometimes leak toxicants.

Birds can absorb a toxic dose in less than a minute but may not die for four days. Pigeons will normally find a protected place out of the sun and wind once they begin feeling the effects of the toxicant. They usually don't fly after that time and so usually die with 20 to 30 feet of the perch, if it was set in a roosting site. There is a secondary poisoning hazard if other animals feed on dead birds. There have also been reports of hawks and owls dying after using the perches. By law, dead birds must be picked up, buried, or burned.

Ornitrol

Ornitrol is a chemosterilant, often called the "birth-control pill" for pigeons. When fed to pigeons, it inhibits ovulation in the female and sperm production in the male. The effects of treatment last for 6 months in the female and 3 months in the male. When applied as directed on the label, it will not kill birds, but populations will slowly decline over the years from the natural mortality in aging pigeon populations.

The manufacturer recommends applications for 10 days two times per year—in the early spring (March) and late summer or early fall. For each 100 pigeons, 7.5 pounds of Ornitrol corn are scattered daily for 10 days. Prebaiting with whole corn for a week will usually be necessary to achieve bait acceptance. Most birds eating Ornitrol would be temporarily sterilized, so care must be taken to avoid feeding non-target species. Research data indicate little or no activity in mammals. There is no secondary poisoning hazard.

Shooting

A possible alternative or supplemental method for eliminating birds is shooting with air-powered pellet guns. Check with local and state law enforcement before discharging any firearms.

- Shoot at night or first thing in the morning in roosting areas.
- Use a high-powered pellet gun—it is relatively accurate, quiet, and short-ranged, and it will not cause structural damage. Many models are available. Some specialists use .22 caliber smooth-bore rifles loaded with Number 12 or Number 9 birdshot or sandshot. These are noisy, however, and too powerful for urban sites.
- Use care—errant shots can be dangerous.

Risks to Non-targets

Most lethal tactics in bird control pose some risk to non-target birds, as well as other animals. Non-targets are protected by various federal, state, and local regulations, as well as by public opinion. Care must be taken to minimize the threat to non-targets or to use tactics that pose the least risk.

- First, identify the non-targets in the area.
- Second, use low-risk tactics.
- Third, modify tactics to minimize risk.
- Fourth, monitor operations to be sure that non-targets are not being adversely affected.

Public Relations

People often react more negatively to one dying bird than to accumulated pigeon droppings on sidewalks or potential risks of parasites and disease from bird roosts. Pigeons and sparrows are seen as pets rather than pests. Consider the public's perception of bird management operations. All bird management programs should put some effort into avoiding "people problems," particularly when using Avitrol or other toxic control techniques.

BIRD DROPPINGS REMOVAL AND CLEANUP

Workers removing large quantities of bird droppings should follow these precautions to minimize risk from disease organisms in the droppings:

- Wear a respirator that can filter particles down to 0.3 microns.
- Wear disposable protective gloves, hat, coveralls, and boots.
- Wet down the droppings to keep spores from becoming airborne, and keep them wet.
- Put droppings into sealed plastic garbage bags and wet the outsides of the bags.
- When finished, and while still wearing the respirator, remove the protective clothing and place the items in a plastic bag.
- Dispose of trash bags. (Disposal should be permissible through standard trash pickup.)
- Wash up or shower.

SUMMARY

Birds provide enjoyment and recreation while greatly enhancing the quality of our lives. Unfortunately, they can become pests at times too—feeding on crops, creating health hazards, roosting on buildings, contaminating food, or creating a nuisance. The major pest birds are pigeons, starlings, and house sparrows, although many birds can become pests in the right (or wrong) situation.

Many laws and regulations protect birds. Though pigeons, starlings, and house sparrows are not directly protected by federal law, their control is often strictly regulated by state and local governments. Public opinion is often strongly against any control measures that kill birds, even pest birds.

Non-lethal bird control methods include habitat modification (limiting food, water, and shelter), exclusion (with netting, porcupine wire, sticky repellents, etc.), and trapping. The most common lethal control measures are Avitrol poison baits and toxic perches. Be extremely careful when using bird poisons so that you do not harm non-target birds and animals.

SECTION 4
CHAPTER 18

Review Questions

Chapter 18: Birds

Write the answers to the following questions and then check your answers with those in Appendix A in the back of this manual.

1-8. Match the following to the appropriate description:

A. Pigeons
B. Starlings
C. House sparrows
D. All of the above

_____ 1. Robin-sized bird, yellow beak (January-June), dark with light speckles.
_____ 2. Nest on buildings.
_____ 3. Introduced into the United States.
_____ 4. Usually stay in one area all year long; pairs mate for life; produce 10 young/year.
_____ 5. Droppings may carry diseases.
_____ 6. Male with black bib, white cheeks, and chestnut upper wing covers.
_____ 7. Congregate in large numbers on high perches; singing and calling can be irritating.
_____ 8. Average three broods per season with four to seven eggs per brood.

9. Which of the following is true about pigeons?

A. They prefer flat surfaces for resting and feeding.
B. They will feed on rooftops or on the ground.
C. Feeding, roosting, and loafing sites are usually separate.
D. All of the above
E. None of the above

10. Pigeons usually make a nest of small twigs, straw, or debris on buildings and other structures.

A. True
B. False

11. Which of the following is true about starlings?

A. They feed at night.
B. They may fly up to 30 miles to their feedings sites.
C. They usually nest on the ground in low shrubbery.
D. All of the above
E. None of the above

12. Which of the following is true about house sparrows?

A. They are nervous around people and will not nest in high-traffic areas.
B. They often create fire hazards by nesting inside transformers and power stations.
C. They prefer to feed on small grains but will also feed on garbage.
D. All of the above
E. B and C

13. The most serious health risk from pest birds is:

A. Disease transmitted by ectoparasites.
B. Inhaling disease organisms from their droppings.
C. Food contamination.
D. There are no serious health hazards associated with pest birds.

14-21. Match the following to the appropriate description:

A. Histoplasmosis
B. Cryptococcosis
C. Ectoparasites

_____ 14. Transmitted to humans by airborne spores from soil contaminated by droppings.
_____ 15. Disease may damage eyes.
_____ 16. Pigeon droppings are the main source of this disease.
_____ 17. Invade buildings from nesting and roosting sites; can irritate skin.
_____ 18. About 50 million people in the U.S. have been exposed to this disease.
_____ 19. Disease causes lung infection.
_____ 20. One form of the disease produces acne-like skin eruptions or ulcers with nodules.
_____ 21. Disease causes flu-like symptoms.

22. FIFRA:

A. Directly protects pigeons, starlings, and sparrows,
B. Directly protects non-target birds,
C. Regulates application of toxicants or repellents.
D. B & C
E. All of the above

23. The first step in controlling pest birds is to:
    A. Attempt to modify habitat.
    B. Use exclusion methods.
    C. Conduct a thorough survey.
    D. Prebait.

24. Nest destruction is ineffective against sparrows and starlings.
    A. True
    B. False

25. Which is true about nest destruction?
    A. Destroying nest once in the spring and once in the summer is recommended.
    B. Treating nest areas within 50 feet of an occupied site with an insecticide/acaracide is recommended to kill ectoparasites.
    C. Nest destruction by spraying nests with high-pressure hoses is cost-effective, eliminates ectoparasites, and cleans droppings and feathers from the nest site.
    D. There is no danger that spraying with high-pressure hoses will damage buildings.
    E. Removing nests will not induce pigeons to leave the area.

26-31. Match the following to the appropriate description:
    A. Netting
    B. Covers
    C. Spikes
    D. Sticky repellents
    E. Ultrasonic devices
    F. Trapping

_____ 26. Ineffective at controlling birds.
_____ 27. Made of plastic; use in warehouses and places where aesthetics are not important.
_____ 28. Porcupine wire; stops birds from roosting on ledges.
_____ 29. Gel makes birds stop trying to land on treated surfaces.
_____ 30. Custom designed for ledges; high cost; use where aesthetics are a concern.
_____ 31. Method more effective for pigeons than starlings and sparrows.

32. The best time to trap pigeons is in the spring.
    A. True
    B. False

33. When using traps:
    A. Leave "decoy" birds in the trap.
    B. Prebait to determine feeding areas/preferences.
    C. Place traps in conspicuous places.
    D. A & B
    E. B & C

34. Place sparrow funnel traps near roosting sites to catch the most sparrows.
    A. True
    B. False

35. Which is true about Avitrol?
    A. At least 50 percent of the flock must consume Avitrol to be effective.
    B. It is not necessary to prebait when using Avitrol.
    C. It does not pose a risk to non-target birds.
    D. Mix a ratio of treated to untreated whole corn for pigeon control.
    E. A & D

36. The main affect of Avitrol on bird control is:
    A. It kills more than 50 percent of the flock.
    B. It inhibits ovulation in females; sperm production in males.
    C. It has flock-alarming properties.
    D. After receiving a toxic dose, birds die four days later.
    E. A & D

37. The main affect of Ornitrol on bird control is:
    A. It kills more than 50 percent of the flock.
    B. It inhibits ovulation in females; sperm production in males.
    C. It has flock-alarming properties.
    D. After receiving a toxic dose, birds die four days later.
    E. A & D

38. When non-lethal bird control is required, which of the following bird-management techniques may be used?
    A. Netting
    B. Avitrol
    C. Ornitrol
    D. A & C

39. Which is NOT true when using Avitrol whole corn for pigeon control?

    A. Only 5 to 15 percent of the flock needs to be affected for Avitrol to be successful.
    B. Prebaiting with untreated corn may be necessary for 3 days up to 3 weeks.
    C. Cardinals, blue jays, and doves will not eat whole corn.
    D. To prebait, place about twenty ¼-pound piles of bait on a 5,000-square-foot roof.
    E. The goal of prebaiting is to get at least 40 percent of the birds to accept the bait.

40. For Ornitrol to be effective:

    A. Apply for 10 days 2 times/year.
    B. Prebait with whole corn for a week.
    C. Apply for 20 days 3 times/year.
    D. A & B
    E. B & C

41. Clients should be made aware that toxic perches do not pose a hazard to humans.

    A. True
    B. False

42. Ornitrol, unlike Avitrol, does not pose a risk to non-target birds.

    A. True
    B. False

43. Non-target birds are protected by federal and state laws but not by local laws.

    A. True
    B. False

44. Public opinion should be considered when deciding on a bird control program.

    A. True
    B. False

45. After cleaning up bird droppings, remove your respirator, then remove your protective clothing and place in a plastic bag.

    A. True
    B. False

46. What steps should be taken to minimize risks to non-target birds?

SECTION 4

CHAPTER 19

OTHER VERTEBRATE PESTS

LEARNING OBJECTIVES

After completely studying this chapter, you should be able to:

- Identify common vertebrate pests.
- Discuss the habitats and life cycles of vertebrates that may be pests.
- Describe public health concerns associated with vertebrate pests.
- Describe situations in which vertebrates are considered pests.
- Know what precautions to take when working with vertebrate pests.
- Discuss the chemical and non-chemical alternatives in vertebrate control and management.

Although rats, mice, and birds are the vertebrate pests most commonly encountered in the urban environment, other vertebrates sometimes become pests, too. Some of these animals become pests when they wander into residential areas from nearby wild areas or parks; examples of these are **skunks, raccoons,** and **opossums.** Some vertebrate pests have taken to living along with people—next to or sometimes inside buildings—e.g., **bats** and **squirrels.**

Whatever the pests, sometimes they must be controlled—because they are often game animals or are otherwise protected, most control actions will be non-lethal.

BATS

Bats are unique in the animal kingdom—they are the only true flying mammals. A thin membrane of skin stretches from the long, modified front legs to the back legs and then to the tail. The bones in the bat's "fingers" are greatly elongated and support the wings.

Bats in the United States are almost always beneficial. Many bats feed on insects and can consume up to half their body weight in insects in one feeding. Occasionally, however, they become a nuisance inside buildings or pose a public health problem.

The bats that most often become a problem around people are the ones that live in colonies or groups. Such as little brown bats and big brown bats. These species sometimes hibernate or roost inside buildings.

Roosting and hibernating sites may occur in building attics, wall and ceiling voids, belfries, chimneys, unused

Figure 19.1. Little brown bat, ***Myotis lucifugus.***

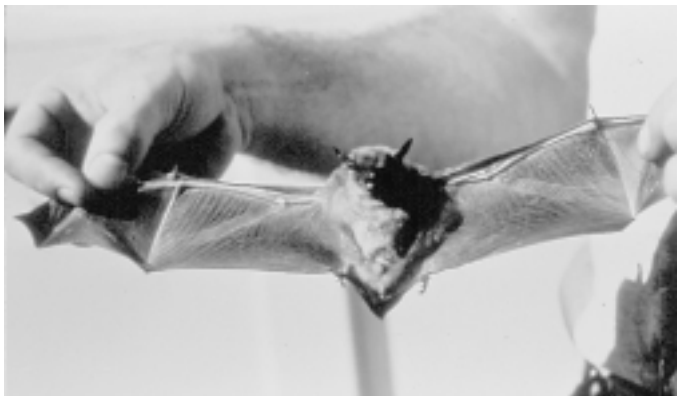


Figure 19.2. Big brown bat, *Eptesicus fuscus*.

furnaces, and the like. The bats' droppings and urine can cause a foul odor and stains in walls and ceilings. Their squeaking and scrambling noises can be intolerable to residents of the building.

Bats and Disease

Bats are associated with a few diseases that affect people. Rabies and histoplasmosis are the most serious. Rabies is a dangerous, fatal disease. However, the bat's role in transmission has been greatly exaggerated. Although bats are confirmed carriers of the disease, only a few human fatalities have been attributed to bat bites. Nevertheless, use care when handling bats.

Bat bites should be considered potential rabies exposure.

- Because most bats will try to bite when handled, they should be picked up with heavy gloves, forceps, or a stick.
- If a bat has bitten someone, it should be captured without crushing its head.
- Refrigerate it (don't freeze it).
- Take it to the local health department for testing.

The incidence of histoplasmosis (discussed in detail in the chapter on birds) being transmitted from bat droppings to humans is not thought to be high.

- When working in a bat roosting site with lots of accumulated droppings, wear a respirator and protective clothing, and follow the safety procedures outlined in the chapter on birds.

Habits of Bats

During warm weather, bats feed on flying insects in late afternoon, evening, and early morning. They are not active in bright daylight. If you see a bat at this time, it has either been disturbed from its daytime resting place or is sick. When not in flight, they rest in dark hiding and roosting sites (e.g., caves, buildings, and hollow trees). Bats are able to enter these places of refuge through holes as small as $^{3}/_{8}$ inch in diameter.

Bats capture flying insects by echolocation—they emit high-frequency sounds inaudible to humans and similar to sonar. They also make audible squeaking sounds to communicate with other bats.

In much of the country, bats migrate or hibernate when the weather turns cold. Sometimes they hibernate in hanging clusters inside buildings. Depending on the species and geographic location, they breed from late spring to midsummer. Young bats grow rapidly and can fly 3 to 7 weeks after birth.

Inspection

Look for two things:

- Entry and exit points of the bats.
- The location of the roost.

Entry and exit points. A building in poor repair will have seemingly unlimited entry points.

- Look for loose flashing, vents, shingles, or siding that bats can squeeze through or under.
- Look for damage and openings under eaves and soffits, at cornices, louvers, and doors; by chimneys and windows; and anywhere pipes or wiring enter.
- Notice droppings under openings, smudges around holes, and odors.
- Bats can be observed at twilight as they leave the building to feed. The best time to observe the bats and pinpoint major exit and entry points is usually from just before to an hour after sunset.
- Station one or more observers on each side of the building, looking up towards the roof.
- Listen for squeaking at the exits just prior to flight.
- If the night is chilly or rainy, the bats may not come out.

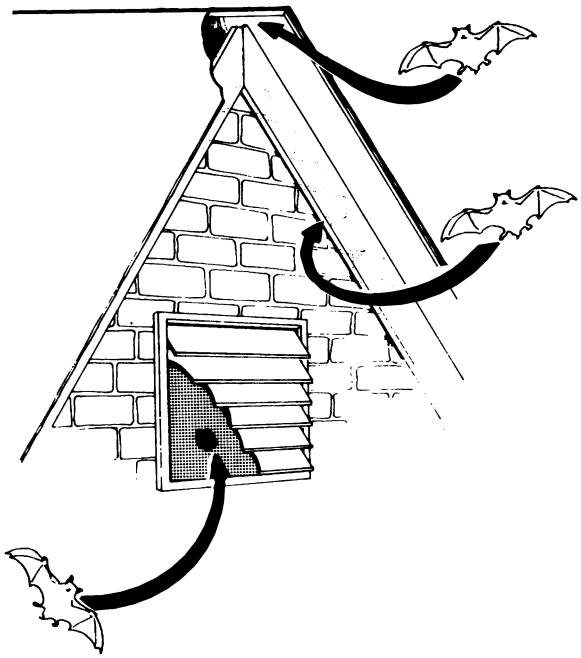


Figure 19.3. Common entry points for bats in a building.

Location of roost.

- Look inside in attics and unused rooms during daylight.
- Check inside the chimney and vents.
- Bang on the walls and listen for squeaks and scratches as roosting bats are disturbed.
- Check behind shutters.
- Look for bat droppings. They will be found below roosting bats. Their droppings look like mouse droppings. However, bat droppings contain wings, legs, and other body parts of insects not found in mouse droppings. Bat droppings often accumulate to a depth of several inches or more.
- Smell for bats in large roosts. Roosting sites have a very pungent and penetrating odor, musky and sweet, that comes from rotting droppings and bat urine.

Control and Management of Bats

Chemical control is no longer an option for eliminating bats. No pesticides are currently registered for bat control by the EPA. The best way to get rid of bats roosting in a building is through bat-proofing.

Bat-proofing. Making a building "bat-proof" means sealing or screening all of the openings bats use to enter. It can be a difficult job because, in many cases, all upper openings 3/8 inch and larger must be sealed. However, this is the only permanent method of ridding a building of bats.

Complicating the process, is the fact that you have to be certain there are no bats inside before sealing the building. Otherwise, you will have created a bigger problem by trapping the bats inside.

June and July are peak months for bat complaints in much of the country. Unfortunately, this is the worst time of the year for control. At this time, bats are rearing young in their colonies. The young can not fly and so stay in the roost. Bat-proofing during this period will trap the young bats inside. They will die and rot and smell. They may also crawl and flutter into living areas.

The best time of year to bat-proof a building is either in late fall after bats have left for hibernation or in late winter and early spring before the bats arrive. If bat-proofing must be done in summer, it should be done after mid-August.

- Seal all but one or two principal openings.
- Wait 3 to 4 days for the bats to adjust to using the remaining openings.
- Then seal those openings some evening just after the bats have left for their nightly feeding.
- "Bat valves" can also be used. These are placed over the remaining openings and allow the bats to leave but not to return.

Standard bat-proofing materials include $^1/_4$-inch hardware cloth, screening, sheet metal, caulking, expanding polyurethane foam, steel wool, and duct tape—the same things used for rodent-proofing. Old, deteriorated buildings have more openings than can be sealed economically. Large sections of plastic bird netting can be draped over the roof areas of old buildings to keep out bats at a reasonable cost.

Bat repellents. If bat-proofing is not possible or bats need to be forced out of a building before it is bat-proofed, the bats can sometimes be repelled from their roost. At this time, only one chemical is registered as a bat repellent. Naphthalene crystals or flakes can be spread on attic floors or placed in voids. The crystals are most effective in confined air spaces. Three to 5 pounds will treat an average attic.

Though naphthalene may repel the bats, it vaporizes and disappears in a few weeks and the bats often return. Many humans dislike the smell of naphthalene as much as bats do; some people are very sensitive to the smell of naphthalene and should avoid all contact.

Bright lights have had some success in repelling bats.

- On commercial buildings, floodlights can be pointed at the bats' entry points to keep them from entering. (Of course, the bright lights may attract insects too, which is the bats' food.)
- Attics can be illuminated with four or more bulbs. Ensure that all corners of the attic are illuminated.
- Drafts of cool air from fans and air-conditioners have, on occasion, kept bats from roosting in a poorly sealed attic.
- Ultrasonic devices do not repel bats.

A single bat. When a single bat finds its way into a home, office, or store, it will usually find its way out again. When it does not, capture the bat with an insect net, a coffee can, or even with a gloved hand. The bat can be released or destroyed. A glue board attached to a broom handle can be used to reach a bat high in a corner or at the apex of an attic.

TREE SQUIRRELS

Tree squirrels are found in forest areas throughout most of the United States. Many species have adapted well to suburban and city life. Occasionally, these squirrels enter buildings and cause damage or disturbance. The most common species that become pests are the gray squirrel, red squirrel, flying squirrel, and fox squirrel.

Tree squirrels usually build their nests in trees. They also may store food and find shelter in attics and garages. Probably the primary way squirrels become pests is by scrambling and scratching inside attics and in wall voids. They may travel on power lines and short out transformers. They like to gnaw on wires.

The legal status of squirrels varies greatly with geographic area and species. Many are classified as game animals. Some are protected. Be sure to check with local game conservation officers if you plan any kind of lethal control or trapping program.

Figure 19.4. Gray squirrel, *Sciurus* spp.

Figure 19.5. Fox squirrel, *Sciurus niger.*

Control and Management of Tree Squirrels

Squirrel-proofing. Step one in eliminating a squirrel problem in a building is to find out where the squirrels are entering. Remember that squirrels will be coming and going each day. Common points of entry include damaged attic louvers, ventilators, soffits, joints of siding, knotholes, openings where utility wires or pipes enter, chimneys, and flashing. Squirrels may gnaw directly through siding and shingles, too.

- Use heavy gauge ½-inch hardware cloth or sheet metal to seal most openings.
- Make other suitable repairs as for rat-proofing.
- Squirrels can be stopped from travelling on wires by installing two-foot sections of 2 to 3 inch diameter plastic pipe. Split the pipe lengthwise, spread the opening apart, and place it over the wire. The pipe will rotate on the wire and the squirrel will tumble off. Be careful near high-voltage wires.

Squirrels often use overhanging branches as highways to rooftops. Tree branches should be trimmed back 10 feet from the building. If the branches can't be trimmed, a 2-foot-wide band of metal fastened around a tree 6 to 8 feet off the ground, keeps squirrels from climbing up the tree and jumping to the building.

Repellents. Naphthalene has been used (in the same way as for bats) to keep squirrels out of attics, particularly in summer homes and camps that are unoccupied in winter. There is at least one sticky repellent product for squirrels. It is similar to the sticky repellents used in bird control. Apply it to ledges, gutters, windowsills, and the like, to keep squirrels off.

Trapping. Live trapping with box or wire traps can be used to remove one or a few squirrels from a building. Traps should be left open and unset for a few days, surrounded by bait, so that the squirrels get used to them. Good baits include peanuts, nutmeats, peanut butter, whole corn, sunflower seeds, or rolled oats. Then the trap can be set. Good trap locations include the roof, the base of nearby trees, or in the attic itself.

Squirrels are nasty biters. Handle them carefully. Experts differ on whether squirrels should be released or killed. If they are released, do so at least 5 miles away so that they do not return.

Where lethal control is permitted, rat snap traps can be used to kill squirrels in attics. The bait should be tied to the trigger and the trap nailed or wired to a beam.

GROUND SQUIRRELS AND CHIPMUNKS

A number of species of squirrels and chipmunks occasionally become pests in and around buildings. The major concern is that they burrow around foundations, in lawns, on golf courses, and in gardens. The ground squirrels, in particular, can have extensive burrows with large mounds, especially along roads and ditch banks. On occasion, burrows beneath buildings have caused structural damage.

Ground squirrels can transmit diseases (such as tularemia and plague) to people, particularly when populations are dense.

Both ground squirrels and chipmunks are active during the day and are easily seen when foraging. But they spend much of their time in their burrows. In winter, most ground squirrels and chipmunks go underground and stay inactive. In some areas, ground squirrels will go into a summer hibernation when temperatures are high.

Ground squirrels are primarily vegetarians, feeding on grasses. When vegetation dries up, they switch to seeds, grains, and nuts. Chipmunks eat both plant and animal material, from seeds, nuts, insects and worms to songbirds and frogs.

Control and Management of Ground Squirrels and Chipmunks

Ground Squirrels

Control is usually required only in severe infestations. Several important steps must be taken if a control or management program is to succeed:

- Correctly identify the species causing the problem.
- Alter the habitat, if possible, to make the area less attractive to the squirrels.

- Use the most appropriate control method.
- Establish an inspection or monitoring program to detect reinfestation.

Ground squirrels are generally found in open areas. However, they usually need some kind of cover to survive. Removing brush piles and debris will make the area less attractive to the squirrels and will facilitate detection of burrows and improve access during the control program. Ground squirrels can be controlled with traps, rodenticides, and fumigants.

Figure 19.6. Ground squirrel, *Citellus* spp.

Trapping. Trapping is a practical means of controlling ground squirrels in limited areas where numbers are small. Live traps are effective but present the problem of disposal of a live squirrel. Because squirrels can carry disease, check state and local laws regarding their release at some new location.

For the smaller species, rat snap traps can be effective.

- Place traps near burrow entrances or runs and bait with nuts, oats, barley, or melon rind.
- Place traps under a box if any non-targets might be killed in the trap.

Rodenticides. Rodenticides are the most cost-effective way of controlling large populations of ground squirrels. A number of products are registered for this use. Grain baits are most effective when squirrels are feeding on grains and seeds.

- Place rodenticides in burrows or in protected bait stations according to the label directions.

Fumigation. Ground squirrels can also be killed by gassing their burrows. Aluminum phosphide tablets or smoke cartridges are most commonly used. Fumigation is most effective when soil moisture is high; moisture helps seal the tiny cracks in the burrow walls. Fumigation is not effective during periods of hibernation because the squirrels plug their burrows. Spring is normally considered to be the best time for burrow fumigation. Fumigation is not a good choice adjacent to buildings because of the risk that the fumigant gas could find its way into the structure.

Chipmunks

Only rarely do chipmunks become a serious pest problem. In most cases, lethal control is unnecessary. Altering the habitat may cause the chipmunks to move.

- Chipmunk-proof the building to prevent entrance.
- Remove objects such as logs, stones, and debris close to a structure that may be provide an attractive denning environment.

Trapping. Live trapping and relocating chipmunks (where permitted) is considered a humane method of control. Effective baits include peanut butter, nuts, sunflowers, seeds, oats, bacon, and apple slices. Relocation should be done into remote forest areas at least 5 miles from the trap site.

Rat snap traps can also be used effectively. Traps should be placed at den entrances and baited with an apple slice or perhaps with some peanut butter. Seeds and nuts should not be used because they will attract ground-dwelling birds.

Figure 19.7. Chipmunk, *Tamias* spp.

Poison baits that are labeled for chipmunk control can be used as described for ground squirrels. Because chipmunk burrows are long, difficult to find, and often near buildings, burrow fumigation is not usually a recommended control tactic.

MOLES

Moles (*Scalopus* spp.) are not rodents, but relatives of the insectivores (insect eaters) such as shrews and hedgehogs. In their search for food, moles burrow in lawns, meadows, stream banks, and open woodlots, creating elaborate underground tunnels. They feed on earthworms and insect larvae (grubs). Only rarely seen above ground, moles are 4 to 9 inches long, including the tail, with long dark gray or brown fur. Eyes are tiny, like a pinhead, and the tail and feet are usually pink. They have no visible ears. There are seven species in the United States.

As they burrow, they sometimes damage plants, but the major problem with moles is the mounds and ridges that

disfigure lawns. As they tunnel just below the surface, moles raise the sod up with their front digging feet, looking for food or new tunneling sites. They can push up surface tunnels at the rate of a foot per minute if the soil is loose. They prefer loose, moist soil shaded by vegetation.

Figure 19.8. Eastern Mole, *Scalopus aquaticus.*

Control and Management of Moles

Though time consuming, using traps is the most effective method of control. Killing moles with fumigants or poison baits is not effective.

To find out which parts of the surface tunnels are active and which are abandoned, tramp down mole tunnels in several places over the yard and mark flattened sections with a peg or wire flag. If the tunnel has been pushed back up the next day or so, a trap should be set in that place.

Two types of traps are in general use: harpoon traps and chokers. A harpoon trap consists of two prongs that straddle the tunnel and a set of spring-driven spikes. The spikes are raised above the tunnel and catch in the trigger release. When the mole triggers the trap, the prongs are released and driven through the sod, impaling and killing the mole.

A choker trap consists of a cast metal frame with two spring-retractable loops. Two slits are cut in the tunnel and the loops placed inside. When the mole triggers the trap, it is immediately crushed.

- When using traps, place a plastic pail with a warning sign over each trap.
- An average set will require three to five traps per acre.
- Check the traps every couple of days.
- After no results for 3 to 4 days, move the traps to new locations.

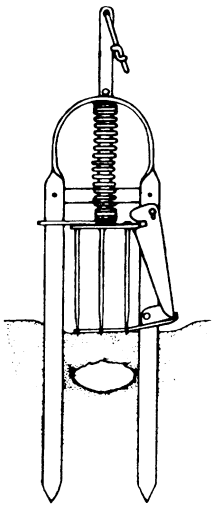


Figure 19.9. A harpoon trap properly set in a surface runway (ridge). A narrow portion of the runway (1 to 1 1/2 inch) is collapsed halfway down, the trap is inserted so that the support prongs straddle the runway, and the trigger rests lightly on top of it. Plastic pails can be placed over traps to prevent animals or children from tampering with them.

SNAKES

Most snakes are non-poisonous, harmless, and beneficial. But few people want them in their homes. In general, poisonous snakes have a large triangular head, a pit between the eye and nostril, and vertical and elliptical pupils. They may also have rattles on their tail, noticeable fangs, and a single row of scales between the vent (anal opening) and the tip of the tail. When unsure, of course, assume that the snake may be poisonous and protect yourself accordingly. The poisonous snake found in Michigan is the eastern massasauga *(Sistrurus catenatus)* rattlesnake. Encountering other poisonous snakes in Michigan is highly unlikely.

Snakes are predators. Depending on the species, their diet may include insects, rodents, frogs, birds, worms, or toads. Some snakes hibernate in dens during the winter, sometimes under houses. At certain times of the year, they may enter buildings for warmth, shade, or moisture, or in search of prey. When managing a snake problem, keep in mind that the snake may be a protected species in Michigan.

Figure 19.10. Garter snake, *Thamnophis sirtalis.*

Control and Management of Snakes

If snakes are a regular problem, the best solution is to eliminate snake hiding places.

- Clean up brush piles, woodpiles, rock piles, and other debris.
- Keep shrubbery away from foundations.
- Cut high grass.

Often, snake problems follow rodent problems. Eliminate the rodents—the snakes' food—and the snakes will move elsewhere.

- Eliminate rodent food and harborage.
- Mow grass short to expose rodent runs.

Snakes often enter structures through broken block foundations, cracked mortar, and damaged vents. These should be repaired.

In a rattlesnake-infested area, a snake-proof fence can be installed around a backyard or play area.

- Bury galvanized 36-inch-wide, 1/4-inch-mesh hardware cloth 6 inches in the ground and slant outward at a 30 degree angle.
- Keep all vegetation away from the fence.

Snake removal. If a snake gets into a house or other building, several methods are available to remove it:

- Place damp burlap sacks on the floor and cover them with dry sacks. Check them every few hours to see if the snake has crawled underneath. The snake and bags can be lifted with a shovel and taken outside. The snake can be killed or released.
- Rat glue boards will capture all but the largest snakes. The glue boards should be tied down or attached to a plywood base. Place the glue boards along wall and floor junctions. Captured snakes may be killed or released. Before release, pour vegetable oil over the snake and glue to loosen it.
- Expanded trigger rat traps set in pairs along wall and floor junctions can kill smaller snakes.

SKUNKS, RACCOONS, AND OPOSSUMS

These three vertebrates are considered together because they are similar pests with similar management and control recommendations. Management of these animals almost always involves exclusion and/or live trapping.

Skunks

Two kinds of skunks may become pests—the striped skunk and the spotted skunk. The striped skunk is about the size of a large house cat and has two broad white stripes running from the back of the head to the large, bushy tail. Spotted skunks are about half that size, with four irregular stripes beginning behind the eyes and below the ears.

Skunks are nocturnal. They do not hibernate but may sleep through cold weather periods. They usually live in underground burrows, hollow logs, or rock piles. They may decide to live under houses, sheds, cabins, or storage buildings.

Of course, the main problem with skunks is their odor. They become pests when they change their dietary selections from rodents, insects, and wild fruit to garden crops, garbage, and lawn insects, and locate their habitat closer to humans. Another major problem in some areas of the country is the transmission of rabies.

Figure 19.11. Striped skunk, ***Mephitis mephitis.***

Raccoons

Raccoons are common throughout North America. They are easy to recognize with their black facemask and black-, brown-, and white-ringed bushy tail. They have long, thick fur with a thin muzzle and pointed ears. Their feet are well adapted to climbing. They are large animals, weighing between 10 and 25 pounds.

Their sense of hearing, sight, and touch are well developed, while those of taste and smell are not. They are commonly found near streams, lakes, and swamps, and they often do quite well in suburban areas and even in city parks. Raccoons den inside hollow trees or logs, rock crevices, deserted buildings, culverts, storm sewers, chimneys, attics, and crawlspaces. More than one den may be used.

Mostly active at night, raccoons may be seen at dawn or dusk and sometimes even in the middle of the day. Winter months are spent in the den, but they do not hibernate. They may become active during warm spells.

Raccoons feed on animals and plants. In the spring and summer, they feed on crayfish, mussels, frogs, and fish. In the fall, they switch to fruits, seeds, nuts, and grains. They also eat mice, squirrels, and birds, and are quite happy knocking over a garbage can. Raccoons, too, can transmit rabies.

Figure 19.12. Raccoon, ***Procyon lotor.***

Opossums

Opossums, which are related to kangaroos, are the only North American marsupial. The opossum is a whitish or grayish animal the size of a house cat with a naked, rat-like tail. Its face is long and pointed with rounded, hairless ears. It grows up to 40 inches long and will weigh up to 14 pounds. The average is 6 to 7 pounds for males and 4 pounds for females. Its tracks look as if they were made by little human or monkey hands.

Opossums prefer to live near streams or swamps. They den in the burrows of other large animals, and in tree cavities, in brush piles, and under sheds and buildings. Occasionally, they move into attics and garages.

They eat nearly everything, from insects to carrion, fruits to grains, garbage to pet food. Opossums are active

at night. Their mating season is January to July, and they may raise two to three litters per year. Most young die in their first year. Those that survive may live up to 7 years.

Opossums move slowly. Their top speed is about 7 miles per hour. When threatened, opossums climb trees or go down into burrows. If cornered, they may growl, hiss, bite, screech, and exude a smelly green fluid from their rear end. If these defenses aren't successful, they may play dead. They have the reputation of being stupid, but scientists consider them to be smarter than domestic dogs.

The main complaint against opossums is that they get into garbage, bird feeders, or pet food left outside.

Figure 19.13. Opossum, *Didelphis marsupialis.*

Control and Management of Skunks, Raccoons, and Opossums

Exclusion. These animals can be prevented from entering buildings by repairing breaks in foundations and screening crawlspace vents with hardware cloth.

- If the animal is currently living under the building, seal all openings but one, then sprinkle a tracking patch of talc at the opening.
- Examine the area after dark. If tracks show that the animal has left, close this last opening immediately.
- Seal attic openings.
- Cap chimneys with a wire cage or other animal-proof cover.

When excluding animals in spring or early summer, be aware that young may also be present. Be sure that all animals have been removed before sealing the building. Otherwise, a serious odor problem from a dead animal could result.

Live Trapping. The best way to remove animals from around buildings is to trap them. Know your state and local regulations before releasing a trapped animal. Some areas prohibit releasing a trapped animal, especially skunks and raccoons, because they carry rabies. State fish and game laws may also regulate the capture and release of some of these animals.

- If the animal must be killed, follow all appropriate regulations.
- If the animal is to be released, do it far away from human dwellings. Try to use what you have learned about the biology of the animal to find a suitable habitat. The release site for these large animals should be over 10 miles away.
- Remember to check state and local regulations.
- Set traps as close to the den as possible or place them where damage is occurring—e.g., at corners of gardens or breaks in stone walls, or along obvious animal trails.
- Set multiple traps in a number of locations.
- Since these animals are active at night, check traps at least every morning; preferably twice a day.
- Check traps often to spot and release non-target animals.
- There is obviously a special problem when trapping skunks. Skunks don't like to "shoot," if they can't see their target, so cover all but the trap entrance with burlap or canvas before placing the trap, or use a commercially sold skunk trap. Approach the trap slowly and transport it gently.

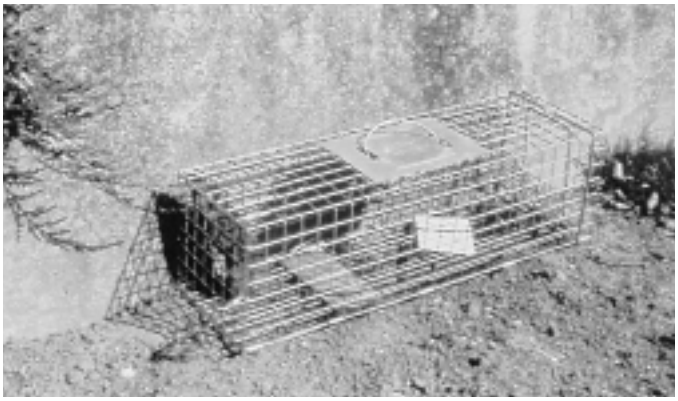


Figure 19.14. One type of live trap.

To release a trapped skunk, stand more than 20 feet away and release the trap door using a string or fishing line.

The best baits for each animal are listed below:

Skunk: Chicken parts and entrails, fresh fish, cat food, sardines, eggs.

Raccoon: Chicken parts and entrails, corn, fresh fish, sardines.

Opossum: Apple slices, chicken parts and entrails, fresh fish, sardines.

The best preventive measure for skunks, raccoons, and opossums is to establish a good level of sanitation in a neighborhood. Remind clients that released vertebrates must fight their way into new territory to establish themselves and that overcrowded habitat results in increased risk of disease and marginal resting sites. Prevention is the most humane way of managing vertebrate pests.

SUMMARY

Almost any vertebrate animal may become a pest by wandering where it is not wanted. Sometimes it will leave by itself; at other times, it will need to be controlled. Most vertebrate control actions will be non-lethal because they are often game animals or otherwise protected. Exclusion is often the preferred method. Live trapping is the most common solution for larger vertebrates, such as raccoons, skunks, and opossums. Be aware of state or local laws regarding the release of trapped animals in other areas. There may be concerns about the spread of disease (rabies, in particular). In these cases, the trapped animal must be killed or turned over to wildlife officials.

SECTION 4
CHAPTER 19

Review Questions

Chapter 19: Other Vertebrate Pests

Write the answers to the following questions and then check your answers with those in Appendix A in the back of this manual.

1. Which of the following is true about bats?
   A. They are usually beneficial to the environment.
   B. Most feed on animal blood.
   C. Many feed on insects.
   D. A and C

2. Two diseases associated with bats are:
   A. Rabies and histoplasmosis.
   B. Histoplasmosis and cryptococcosis.
   C. Rabies and cryptococcosis.
   D. Leptospirosis and histoplasmosis.
   E. Rabies and Leptospirosis.

3. When bat-proofing seal all upper openings that bats use that are:
   A. 1/8 inch or larger.
   B. 3/8 inch or larger.
   C. 5/8 inch or larger.
   D. 1 inch or larger.
   E. 1 1/2 inches or lager.

4. List some areas you would inspect on a building to find bat exit and entry points.

5. The best time to control bats is in:
   A. Midsummer and late winter.
   B. Late fall and late winter.
   C. Early fall and mid-summer.
   D. Early fall and early winter.

6. Young bats begin to fly and leave the roost in June and July.
   A. True
   B. False

7. Which may be used to repel bats?
   A. Ultrasonic devices
   B. Bright lights
   C. Naphthalene flakes
   D. Sticky repellents
   E. B & C

8. Always wear a respirator while working in a bat roost.
   A. True
   B. False

9. Which of the following control methods is never used against tree squirrels?

   A. Trimming tree branches that hang over a house

   B. Squirrel-death bait blocks

   C. Squirrel-proofing with ½-inch hardware cloth

   D. Naphthalene repellent

10. List some materials needed for bat- and squirrel-proofing.

11. Ground squirrels can transmit plague to people.

   A. True

   B. False

12. When necessary, and if not prohibited by law, ground squirrels can be controlled with traps, rodenticides, and fumigants.

   A. True

   B. False

13. Release trapped squirrels or chipmunks at least _____miles away.

   A. Two

   B. Three

   C. Five

   D. Ten

14. A small ground squirrel population has made burrows near a building. The best control method is:

   A. Fumigate in the spring when soil moisture is high.

   B. Fumigate during hibernation periods.

   C. Trap them.

   D. Use rodenticides.

   E. A & D

15. Which is the best method for controlling chipmunks?

   A. Fumigate in the spring when soil moisture is high.

   B. Fumigate during hibernation periods.

   C. Trap them.

   D. Habitat alteration.

   E. C & D

16. Under what circumstances might you consider fumigation for control of ground squirrels?

   A. When populations are high and in the spring when soil moisture is high.

   B. When populations are low and in winter during hibernation.

   C. When populations are high and in the winter during hibernation.

   D. When populations are low and in the spring when conditions are dry.

   E. When burrows are located near buildings.

17. Which of the following is true about moles?

   A. Trapping is the most effective control measure.

   B. Poison bait is the most effective control measure.

   C. Moles feed on grass roots.

   D. A and C

18. What is the procedure for trapping moles?

19. Which of the following are acceptable snake control methods?
    A. Clean up brush piles.
    B. Use a snake repellent in a band around the area to be protected.
    C. Eliminate rodent food and harborage.
    D. A and C

20. Inside a home, a snake can be captured by using:
    A. Damp burlap bags.
    B. Rat glue boards.
    C. Rat trigger traps.
    D. A & B
    E. All of the above

21. Control of skunks, raccoons, and opossums almost always involves exclusion or live trapping.
    A. True
    B. False

22. Which is true about skunks?
    A. Mostly active during the day
    B. Hibernate in winter
    C. May live under houses
    D. May transmit rabies
    E. C & D

23. Which is NOT true about opossums?
    A. May hiss, growl and bite if cornered
    B. Less intelligent than skunks and raccoons
    C. Sometimes play dead
    D. Mostly active at night
    E. A & B

24. Describe the procedure for excluding a skunk or raccoon living under a building.

25. Which of the following statements is true concerning trapping skunks, raccoons, or opossums?
    A. Trapped animals should always be released at least ten miles away.
    B. Traps should be checked every 48 hours.
    C. Set only one trap at a time.
    D. All of the above

26. To release a trapped skunk, open the door, then run away quickly.
    A. True
    B. False

APPENDIX A
ANSWERS TO REVIEW QUESTIONS

SECTION ONE – GENERAL PEST MANAGEMENT INFORMATION

Chapter 1
Legalities of General Pest Management

(1) False, (2) B, (3) D, (4) B, (5) D, (6) C, (7) A, (8) False, (9) C, (10) D

(11) Definition, general description, why pesticide is used, general toxicity information (i.e, compound type, where applied, exposure information, amount/rate applied, label compliance), precautionary measures, and instructions to customer on site preparation, precautions, etc.

(12) True, (13) False, (14) D

(15) Unless otherwise specified by the product label, applicators must wear long pants, protective footwear, long-sleeved clothing (short-sleeved allowed if wash or waterless soap is immediately available), and gloves impervious to the pesticide.

(16) False

(17) Site evaluation, description, inspection and monitoring; the concept of threshold levels; the relationship between pest biology and pest management methods; pest population reduction and pest prevention; development and implementation of an IPM program that reduces the possible impact of pesticides; evaluation of an IPM program to determine effectiveness; record-keeping requirements of an IPM program.

(18) D

Chapter 2
Using Equipment in General Pest Management

(1) B, (2) A, (3) C, (4) F, (5) D, (6) E, (7) False, (8) A, (9) C, (10) B, (11) A, (12) B, (13) B, (14) A, (15) False, (16) False, (17) C, (18) A, (19) B, (20) C, (21) D, (22) C, (23) A, (24) D, (25) True, (26) E

(27) Measure a suitable test area similar to that which you will be spraying. A minimum test area of 10 feet by 25 feet (250 square feet) is suggested.

Fill the sprayer with water to a level that is easily recognized.

Spray the premeasured area using the same pressure and technique that you will use when applying the pesticide.

Refill the tank (with water) to the original water level. Be sure to note how much water you added to refill the tank.

Multiply the volume used for the test area by the appropriate number to get the volume of spray mixture you will need to spray 1,000 square feet. Change nozzles or adjust speed or pressure and recalibrate, if necessary.

Determine the amount of pesticide needed for each gallon of water and the amount of spray mixture needed to cover the intended spray area.

(28) How many ounces of insecticide are needed per gallon of water?

$$\text{Amount needed per gallon} = \frac{\text{amount needed per 1,000 square feet}}{\text{volume sprayed per 1,000 square feet}}$$

$$= 3 \text{ ounces}/2 \text{ gallons}$$

$$= 1.5 \text{ ounces/gallon}$$

How many ounces of insecticide per tankful of water?

$$\text{Amount per tank} = \text{tank capacity} \times \text{amount needed per gallon}$$

$$= 5 \text{ gallons} \times 1.5 \text{ ounces per gallon}$$

$$= 7.5 \text{ ounces/tank}$$

(29) How many square feet per tankful?

$$\text{Square feet per tank} = \frac{1{,}000 \text{ square feet feet}}{\text{gallons needed per 1,000 square feet}} \times \text{gallons per tank}$$

$$= \frac{1{,}000 \text{ square feet}}{2 \text{ gallons}} \times 5$$

$$= 2500 \text{ square feet per 5-gallon tank}$$

(30) True, (31) B, (32) C, (33) A, (34) True

Chapter 3
Pest Management and Control

(1) Any unwanted organism.

(2) 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.

(3) A community with its physical and biological supports.

(4) False, (5) C, (6) B, (7) D, (8) C, (9) A, (10) A

(11) The level of pest density that can be tolerated. Advantages: eliminates preventive spraying, curtails excessive pesticide application, and encourages good inspection.

(12) B, (13) C

(14) Pests develop genetic resistance to the pesticide; use a multicomponent approach such as integrated pest management and/or alternate pesticides with different modes of action.

Chapter 4
Pest Management in Food-Handling and Other Specialized Facilities

(1) D, (2) A, (3) True, (4) D, (5) True, (6) False, (7) B

(8) 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).

(9) False, (10) True, (11) B, (12) E, (13) A, (14) B, (15) C, (16) D, (17) F, (18) E, (19) D, (20) C, (21) A, (22) E, (23) B, (24) B, (25) D, (26) E, (27) E, (28) B, (29) E, (30) E, (31) E

SECTION TWO - STRUCTURE-INFESTING PESTS

Chapter 5
Insects and Their Relatives

(1) B, (2) C, (3) A, (4) B, (5) D, (6) A, (7) D, (8) C, (9) A, (10) B, (11) D, (12) D, (13) B

(14) Each stage of insect development may have different habitat requirements. It is important to understand the habits and habitats of each stage so that the appropriate pest control method(s) is (are) selected.

Chapter 6
Cockroaches

(1) A, (2) A, (3) C, (4) B, (5) D, (6) E, (7) E, (8) C, (9) A, (10) B, (11) E, (12) E

(13) Serves to keep cockroaches together in a group in areas of favorable harborage; facilitates mating by keeping adults of both sexes together.

(14) C, (15) B, (16) A, (17) A, (18) A, (19) B, (20) A, (21) A, (22) C, B, A, E, D, (23) E, (24) D

(25) Sanitation (intensive cleaning, remove food source, clean gutters and window wells, etc.)

Habitat alteration (reduce temperature and humidity—i.e., fix leaky sinks, ventilate etc., caulking/painting cracks and crevices, block entry points, remove woodpiles, etc.)

(26) E

Chapter 7
Ants

(1) False, (2) False, (3) False, (4) C, (5) A, A, B, A, B, B, B, A, (6) A, (7) B

(8) Caulk wall penetrations, tighten door and window frames, Repair window leaks, Trim shrubbery away from house, remove firewood/stones, etc. near house, control ant-tended aphids and mealybugs.

(9) B, (10) E, (11) B, (12) D, (13) D, (14) A, (15) B, (16) C, (17) B, (18) B, (19) E, (20) C, (21) A, (22) D, (23) B, (24) E, (25) False, (26) True

Chapter 8
Stored-product and Fabric Pests

(1) A, (2) B, (3) C, (4) A, (5) E, (6) B, (7) C, (8) D, (9) A, (10) E, (11) B, (12) D, (13) C, (14) E, (15) F, (16) D, (17) A, (18) D, (19) D, (20) E, (21) D, (22) C, (23) A, (24) False, (25) D, (26) C, (27) B, (28) A, (29) C, (30) True, (31) D, (32) E, (33) E, (34) B, (35) B, (36) D, (37) A, (38) E, (39) C

Chapter 9
Silverfish and Firebrats

(1) True, (2) C, (3) False, (4) B, (5) C, (6) B, (7) C, (8) D, (9) C, (10) B, (11) C, (12) E

(13) Locate moisture sources, mend leaky pipes, ventilate, dehumidify, eliminate standing water, make grade and guttering changes, dispose of infested materials, relocate stored materials to dry spaces, etc.

(14) Crack and crevice treatment in infested areas (to kill newly hatched); dusts as spot treatments (where there is no drift) or crack and crevice; napthalene flakes in sealed textile storage; and, fogs to eliminate heavy populations

Chapter 10
Fleas

(1) B, (2) A, (3) True, (4) C, (5) E, (6) True, (7) True, (8) A, (9) B, (10) A, (11) C, (12) E, (13) True

SECTION THREE - INVADING PESTS

Chapter 11
Houseflies and Their Relatives

(1) One group of flies is mosquito- or gnat-like with obvious, even somewhat long antennae. Their larvae have a head capsule and usually live in water (examples: midges, fungus gnats, etc.). The rest of the flies, the majority of the species, are usually not mosquito-like but are more robust with very small antennae. The larvae of this group are often maggot-like (examples, houseflies, blowflies, etc.).

(2) C, (3) B, (4) A, (5) A, (6) B, (7) A, (8) B, (9) B, (10) A, (11) A, (12) B, (13) B, (14) A, (15) D, (16) E, (17) C, (18) E, (19) F, (20) F, (21) B , (22) True, (23) True

(24) Caulk cracks and crevices (especially around windows); tighten up around windows and screen vents under roof; liquid pressurized sprays or dusts in wall voids; crack & crevice pesticides around windows and door frames; aerosols or space sprays with large infestations; sticky fly strips in front of windows; residual pesticides only on surfaces not used by people.

(25) Begin by locating the breeding sites: garbage cans, dumpsters, animal manure, etc., and inspect for fly entry points (open doors, etc.). Recommend sanitation methods such as removing garbage twice a week and removing all breeding and food materials: clean spills, drain wet areas, keep loading docks clean, etc. Exclusion can be achieved by caulking and tightening around doors, windows, ventilators, etc., screening entry points, and/or using air curtains or automatic door closers. Pesticide application might include fly strips, baits, aerosol contact sprays, and/or crack and crevice applications in areas where flies hide or enter.

(26) Seek out infested materials that are producing yeast: overripe fruit and vegetables, open or broken cans of fruit and vegetables, sour mops and rags, moist pet food and bedding. Use traps baited with ripe banana to locate the main infested area. Eliminate yeast-producing materials.

(27) B, (28) A, (29) C, (30) A, (31) A, (32) C, (33) False

Chapter 12
Stinging Pests

(1) C

(2) Aerial and underground. Several species of yellow jackets make suspended aerial nests. They attach a paper comb of cells to a structure or plant limb and construct a paper envelope around it. These combs are enlarged, and tiers are added as the colony grows. The envelope is also enlarged to accommodate growth. Many other species nest in the ground and start the first paper comb of cells in an existing hole; later, they add combs and enlarge the hole.

(3) B, (4) C, (5) D, (6) A, (7) F, (8) F, (9) B, (10) A, (11) E, (12) D, (13) D

(14) Remove old nest and scrape the point of attachment to discourage selection by a queen for a new comb; remove ripe fallen fruit; caulk openings in attics, window frames and wall penetrations to discourage overwintering by females; use pressurized sprays that propel spray 8 to 12 feet or use aerosols on extension poles.

(15) When people step on or disturb a colony; when they infest wall voids or attics; when workers swarm around ripe fallen fruit, beer, soft drinks etc. in backyards, at picnics, sporting events, and other gatherings.

(16) False

(17) Clean garbage cans and fit with tight lids; empty cans and dumpsters daily at public places; remove attractive refuse several times a day when yellow jacket activity is high; locate food facilities strategically at public events to avoid luring yellow jackets; clean drink-dispensing machines, screen food-dispensing stations, and locate trash cans away from food-dispensing areas; caulk holes and entry spaces in siding to limit infestations in wall voids and attics, and screen ventilation openings.

(18) A

(19) Insert plastic extension tube from a pressurized liquid spray or aerosol generator in the entrance hole and release the pesticides for 10 to 30 seconds. Plug the entrance hole with dusted steel wool or copper gauze, dust the plug and area around the entrance, cut nest down after yellow jackets are dead.

(20) Pesticide-dusted steel wool can be used to plug holes in wall voids, in aerial and ground nests, and in carpenter-bee tunnels.

(21) C, (22) B, (23) D, (24) A, (25) D, (26) A, (27) A

(28) Dust tunnels or inject with pressurized liquid insecticide. Insert a dusted plug of steel wool or copper gauze into the tunnel; fill the opening with caulk, wood filler, or a wooden dowel.

Chapter 13
Spiders

(1) A, (2) B, (3) A, (4) A, (5) B, (6) B, (7) A, (8) C, (9) C, (10) A, (11) A

(12) Inspect accumulations of logs, wood, bricks, construction materials, as well as stacks of baskets and equipment that have not been moved for some time. Privies, sheds, and inside such things as groundwater meters are potential nesting places. Black widows move into secluded spaces and remain if they are not disturbed. Be careful when reaching into potential black widow nesting places.

(13) Inspect rooms and spaces in a home that are little used by occupants. Examples are guest rooms and furniture, little-used closets, behind heavy furniture, clothes hanging from past seasons without being disturbed or worn. When spiders live outside in the southern portion of its range, look in window wells and accumulations of undisturbed materials near the structure.

(14) Inspect rooms where people have been bitten (often bedrooms); webbing sites in fall; angles of walls and ceilings, door and window facings, in furniture joints, in larger cracks and crevices, in thermostats, and other protected places; look for webs inside jets and burner trains of gas appliances that are inactive during the summer-winter transition period. Other sites are gas stoves and refrigerators in recreational vehicles, gas air conditioners and through-the-wall gas furnaces. The silken obstructions interfere with gas flow; operational failure can be an indication of their presence.

(15) True, (16) E, (17) A, (18) B, (19) D, (20) B, (21) False, (22) True

(23) Wolf spiders, jumping spiders and crab spiders.

Control measures:

Caulk and tighten structures to keep spiders from wandering in.

Remove vegetation and litter from foundation, doorways and window wells.

Modify lighting arrangements that attract flying insects that become spider prey.

Inspect flower arrangements brought inside.

Assure clients that they can swat or vacuum spiders without harm.

Pesticides effective only when used directly on spider habitat.

Use barrier spray around buildings where spiders are an obvious and threatening problem, but follow with other pest management procedures also.

Chapter 14 Ticks, Mites, Bedbugs, and Lice

(1) E, (2) A,C,B,A , (3) D, (4) False, (5) True , (6) A, (7) E, (8) True, (9) A, (10) C, (11) C, (12) D, (13) B, (14) A, (15) D, (16) C, (17) A

(18) The dog can be treated with pesticidal dips, washes, or dusts. The dog's bedding should be washed frequently and the pet should be checked regularly for ticks. The owner may also want to look into flea and tick collars. Keeping the grass cut short around buildings and fences and keeping stray animals out of the yard may also help. Advise pet owner that children should not play with the dog after it has been recently treated. Pesticide sprays or dusts may be used outside on the dog's kennel or resting area; inside, crack and crevice applications can be made where ticks hide. In both cases, warn pet owner that children and pets must stay out of the area until it is dry. Assure clients that brown dog ticks do not transmit disease.

(19) Dab the ticks with alcohol. If the ticks do not release within a few minutes, take some tweezers and grasp the tick at the skin level (not the back end) and pull steadily until the tick is removed. Place the tick in alcohol and keep it for identification. Treat the area with an antiseptic (mouthparts left in the skin will not transmit disease). Note the time and date of removal to calculate possible onset of symptoms. If the tick identified is a deer tick, see a physician. If it is an RMSF carrier, look for symptoms within a week after exposure; see a physician if symptoms develop.

(20) Drag a flannel rectangle across a field or path to collect ticks and take them in for identification at a university Extension Service office. Visit deer-checking stations during hunting season to arrange trapping of mice and counting of ticks. Consult local veterinarians—positive diagnoses of Lyme disease in dogs is a signal that human cases will follow. Interview game conservation agents to learn of host (mice, deer) prevalence and prevalence of disease in hunters and hunting dogs.

(21) Reduce rodent habitat to reduce hosts for larval and nymphal ticks (i.e., keep vegetation short, clean up corn left in edge rows of fields and grain spills, etc.). Make recommendations to conservation personnel such as encouraging deer hunting and the opening-up of woodland edges to encourage hawk and owl predation of mice. Other recommendations might include widening paths in camps and parks, denying public access to areas with high tick populations, etc. Herbicides and mowing may also be used to keep weeds down and reduce rodent habitat.

(22) Permethrin-treated cotton balls in cardboard cylinders must be placed outdoors in places close enough to reach female white-footed mice. The mice will take the cotton balls for use as nesting material. The tick parasites will be killed by permethrin while mice are in the nest. The device must be placed outdoors early enough in the season to kill larval and early nymphal stages of the ticks, which are the stages that parasitize white-footed mice.

(23) Wear long pants tucked into socks. Use insect repellents. Use permethirin formulations labeled for use on clothes. Sulfur powder dusted on socks may help. Schedule regular body inspections for ticks at noon and at bedtime.

(24) False, (25) False, (26) False, (27) A, (28) C, (29) B, (30) B, (31) C, (32) B, (33) True, (34) False

(35) Tighten, caulk, and screen entry routes. Store mattresses in protected areas. Open protective harborage inside (to allow predation) or tighten them up completely. Move woodpiles and keep weeds and shrubs away from the foundation. Eliminate garbage. Use labeled insecticides such as crack and crevice methods for treating harborage, furniture joints, etc. Treated mattresses should be dry before use.

(36) A

(37) First, establish that pesticides should not be used in the school for these pests. Close inspections of pupils and siblings should be made in their homes, especially homes of students where the teacher has observed louse nits in their hair. Emphasize how head lice can be transmitted and that safe preparations to control head lice can be obtained and should be used according to label directions.

(38) D, (39) C, (40) B, (41) B, (42) A, (43) C, (44) A, (45) B, (46) B, (47) E

Chapter 15 Miscellaneous Invaders

(1) B, (2) C, (3) E, (4) D, (5) A, (6) E, (7) True, (8) E, (9) False, (10) E, (11) E, (12) C, (13) A, (14) B, (15) D, (16) D, (17) A, (18) C, (19) B, (20) D, (21) D, (22) C, (23) E, (24) C, (25) B, (26) C, (27) B, (28) E, (29) E, (30) False, (31) E, (32) False

(28) Outside: Dust or spray gravel-covered plastic barrier and/or the mowed grass adjacent to it. Place pesticides near the building (sulfur is a possible miticide). Treat under sheathing, where possible.

Inside: General spot treatment on surfaces. Crack and crevice in structural joints and spaces from which mites emerge. Dust voids. Emulsifiable concentrates, wettable powders, dusts, and pressurized canned pesticides labeled for mite control are effective.

SECTION FOUR - RODENTS AND OTHER VERTEBRATE PESTS

Chapter 16
Rats

(1) B, (2) False, (3) False, (4) E, (5) A, (6) D, (7) B, (8) F, (9) C, (10) B, (11) E, (12) B, (13) D, (14) True

(15) Rats may be moving toxic bait into a location where the label does not permit it to be. Also rats may be hoarding poison bait while feeding on their regular food. Thus, a bait program becomes ineffective.

(16) A, (17) True, (18) A, C, B, D (19) A

(20) Sanitation (clean food spills, close or repair dumpsters, etc.); eliminate hiding places(remove plant ground covers such as ivy near buildings, reduce clutter in rarely used rooms, etc.); rat-proofing (seal cracks and holes in foundations, block openings around water and sewer pipes, screen air vents, caulk and seal doors, etc.).

(21) E, (22) True, (23) False, (24) C, (25) E, (26) False, (27) False, (28) A, (29) False, (30) True

(31) Bait box should be made of metal or heavy plastic; can be secured to floor, wall, or ground; should be clearly labeled with precautionary statements; should be placed in locations inaccessible to pets, children, etc.

Chapter 17
House Mice

(1) D, (2) True, (3) False, (4) D, (5) E, (6) C, (7) A, (8) B, (9) D, (10) B, (11) True, (12) False, (13) A, (14) D, (15) D, (16) E, (17) B, (18) False, (19) True, (20) C, (21) True, (22) A, (23) True, (24) False, (25) C, (26) E

(27) Mice can be living above their main food supply in suspended ceilings, attics, inside vertical pipe runs, and on top of walk-in coolers. Or they can be below, in floor voids, crawl spaces, or under coolers and/or processing equipment.

(28) Store bulk food in mouse-proof containers or rooms; stack packaged food in orderly rows on pallets for easy inspection; keep stored materials away from walls and off the floor; paint a 12- to 18-inch yellow band nest to the wall to detect mouse droppings, sweep often.

(29) Seal large holes in buildings; 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.

Chapter 18
Birds

(1) B, (2) D, (3) D, (4) A, (5) D, (6) C, (7) B, (8) C, (9) D, (10) True, (11) B, (12) E, (13) B, (14) A, (15) A, (16) B, (17) C, (18) A, (19) B, (20) B, (21) A, (22) C, (23) C, (24) True, (25) C, (26) E, (27) A, (28) C, (29) D, (30) B, (31) F, (32) False, (33) D, (34) False, (35) D, (36) C, (37) B, (38) D, (39) C, (40) D, (41) False, (42) False, (43) False, (44) True, (45) False

(46) (1) Identify non-targets in the area. (2) Use low risk tactics. (3) Modify tactics to minimize risk. (4) Monitor operations to be sure that non-targets are not being adversely affected

Chapter 19
Other Vertebrate Pests

(1) D, (2) A, (3) B

(4) Look for loose flashing, vents, shingles, or siding that bats can squeeze through or under. Look for damage and openings under eaves and soffits, at cornices, louvers, and doors, by chimneys and windows, and places where pipes and wiring enter. Remember that twilight is the best time to observe bats leaving a building to feed.

(5) B, (6) False, (7) E, (8) True, (9) B

(10) Quarter-inch hardware cloth for bats (1/2-inch hardware cloth for squirrels), screening, sheet metal, caulking, expanding polyurethane foam, steel wool, and duct tape.

(11) True, (12) True, (13) C, (14) C, (15) E, (16) A, (17) A

(18) Tramp down mole tunnels in several places over the yard. Mark tramped-down sections with a peg or wire flag. If the tunnel has been pushed back up in the next day or so, a trap should be set in that place. Place a plastic pail with a warning sign over each trap. Three to five traps per acre are required. Check the traps every couple of days. If there are no results after 3 to 4 days, move the traps to new locations.

(19) D, (20) E, (21) True, (22) E, (23) B

(24) Seal all openings under the building except one. Sprinkle a tracking patch of talc at the opening. Examine the area after dark. If tracks show that the animal has left, close this last opening immediately.

(25) A, (26) False

APPENDIX B

GLOSSARY

Glossary of Terms for General Pest Management

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. LD_{50} and LC_{50} 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.

CRACK AND CREVICE TREATMENT—The application of small amounts of insecticides into cracks and crevices in which insects hide or through which they may enter a building or travel in it.

CRAWLSPACE—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.

DEFECT 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 (***harborage,*** 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, fungi)—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— Recurved 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—The portion of the label on a pesticide container that gives the name and amount of each 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.

LC_{50}—Lethal concentration. The concentration of a pesticide, usually in air or water, that kills 50 percent of a test population of animals. LC_{50} is usually expressed in parts per million (ppm). The lower the LC_{50} value, the more acutely toxic the chemical.

LD_{50}—Lethal dose. The dose or amount of a pesticide that can kill 50 percent of the test animals when eaten or absorbed through the skin. LD_{50} is expressed in milligrams of chemical per kilogram of body weight of the test animal (mg/kg). The lower the LD_{50}, the more acutely toxic the pesticide.

LEACHING—The movement of a substance with water downward through soil.

MESOTHORAX—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 biorationals.

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.

MOLLUSCICIDE—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 at the narrow connection between the thorax and abdomen of ant species. The nodes may be helpful in identifying of 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.

PHOTODEGRADATION—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, E-2195, Michigan State University Extension.

The Federal Insecticide, Fungicide, and Rodenticide Act as amended. Public Law 92-516 October 21, 1972 as amended by Public Law 94-140 November 28, 1975, and Public Law 95-396 September 30, 1978.

Federal Register, November 7, 1990, Part II Environmental Protection Agency 40, CFR Part 171 Certification of Pesticide Applicator; Proposed Rule.

Region V Office of the EPA, Chicago, Ill.

Michigan 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 C
PESTICIDES USED IN STRUCTURAL PEST MANAGEMENT

Common Name	Oral LD_{50} (mg/kg)	Dermal LD_{50} (mg/kg)	Signal Words
INSECT ATTRACTANTS			
heptyl butyrate muscalure	>23,070	>2,025	Caution
BOTANICALS AND PYRETHROID INSECTICIDES			
allethrin	680-1,000	>11,200	Caution
azadirachtin	>5,000	>2,000	Caution
bifenthrin	54.5	>2,000	Warning
bioresmethrin	450-680		Caution
cyfluthrin	500-800	>5,000	Caution
cypermethrin	247		Warning
cyphenothrin	310-419		Warning/Caution
d-limonene			Warning/Caution
d-trans allethrin	425-860		Caution
deltamethrin	129-139	>2,000	Warning
empenthrin	1,680-2,280		
esfenvalerate	74-458	>5,000	Warning
fenfluthrin	85-120	1,535-2,500	
fenothrin	>10,000	>5,000	Caution
fenvalerate	451	>2,500	Caution
fluvalinate	>3,000	>2,000	Warning
lambda-cyhalothrin	19-79	1,293-1,507	Warning
linalool			Caution
permethrin	2,000->4,000	>4,000	Warning
phenothrin	>5,000	>2,000	Caution
pyrethrins, pyrethrum	200-2,600	>1,800	Caution
resmethrin	1,500-4,240	2,500->3,040	Caution
rotenone (derris)	60-1,500	>1,000-3,000	Caution
tetramethrin	>4,640	>15,000	Caution
tralomethrin	99-3,000	>2,000	Warning/Caution
CARBAMATE INSECTICIDES			
bendiocarb	46-156	566-800	Warning/Caution
carbaryl	307-986	>500->4,000	Caution
propoxur	83-104	>1,000->2,400	Warning/Caution
CHLORINATED HYDROCARBON INSECTICIDES			
dicofol	575-1,331	1,000-1,230	Caution

Common Name	Oral LD_{50} (mg/kg)	Dermal LD_{50} (mg/kg)	Signal Words
INSECT GROWTH REGULATORS			
Chitin Inhibitors			
diflubenzuron	4,640->10,000	>4,640	Caution
hexaflumuron	>5,000	>5,000	Caution
iufenuron	>2,000	>2,000	Caution
Juvenoids			
hydroprene	>5,100	>5,100	Caution
methoprene	>34,600	3,038->3,500	Caution
pyriproxyfen	>5,000	>2,000	Caution
FUMIGANTS (AVT = acute vapor toxicity)			
chloropicrin	250		Danger
methyl bromide	AVT = 200 ppm		Danger
napthalene	2,200		Caution
paradichlorobenzene	500-5,000	>2,000	Warning
phosphine	AVT = 200 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 (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
sulfluramid	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

Common Name	Oral LD_{50} (mg/kg)	Dermal LD_{50} (mg/kg)	Signal Words
INSECT REPELLENTS			
R-874	8,500		Caution
deet	1,950-2,000	10,000	Caution
dibutyl pththalate	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			
piperonyl butoxide	6,150->7,500	>7,950	Caution
MGK 264	2,800	>9,000	Caution
AVICIDES			
fenthion	255-740	1,680-2,830	Warning
4-aminopyridine	20		Caution/Danger
RODENTICIDES			
Antigoaculants			
brodifacoum	0.27	50	Caution
bromadiolone	1.13		Caution
chlorophacinone	20.5		Caution
difethialone	0.51-0.56		Caution
diphacinone	1.86-2.88		Caution
warfarin	1-186		Caution
Nonanticoagulants			
bromethalin	2.0-5.9		Caution
cholecalciferol	40-50		Caution
strychnine	1-30		Danger
zinc phosphide	45		Danger/Caution
OTHER NEUROTRANSMITTER DISRUPTORS			
imidicloprid	1,858-2,591	>2,000	Caution
fipronil	100	>2,000	Warning

Sources: *Commercial and Experimental Organic Insecticides* (College Park, Md.: Entomological Society of America, 1985), 105; *Farm Chemicals Handbook* (Willoughby, Ohio: Meister Publishing, 1996); and *The Pesticide Manual,* 10th ed. (Surrey, England: British Crop Protection Council, 1994).

NOTE: Materials are listed by common chemical name; basic toxicity data (against laboratory animals), and signal words are generally listed on their product labels.

APPENDIX D

CONVENIENT CONVERSION FACTORS

Multiply	By	To Get
Acres	0.405	Hectares
Acres	4,047.0	Square Meters
Acres	4,840.0	Square Yards
Acres-feet	43,560.0	Square feet
Acre-feet	1,233.49	Cubic Meters
Acre-feet	43,560.0	Cubic Feet
Acre-feet	325,850.58	Gallons
Bushels	0.0461	Cubic yards
Bushels	1.2437	Cubic feet
Bushels	4.0	Pecks
Bushels	32.0	Quarts (dry)
Bushels	35.24	Liters
Bushels	64.0	Pints (dry)
Bushels	2,150.42	Cubic inches
Centimeters	0.3627	Inches
Centimeters	0.01	Meters
Centimeters	10.0	Millimeters
Cubic centimeters	0.0610	Cubic inches
Cubic centimeters	0.03381	Ounces (liquid)
Cubic centimeters	1.0	Milliliters of water
Cubic centimeters	1.0	Grams of water
Cubic feet	0.0283	Cubic meters
Cubic feet	0.0370	Cubic yards
Cubic feet	0.8040	Bushels
Cubic feet	7.4805	Gallons
Cubic feet	25.71	Quarts (dry)
Cubic feet	28.32	Liters
Cubic feet	29.92	Quarts (liquid)
Cubic feet	51.42	Pints (dry)
Cubic feet	59.84	Pints (liquid)
Cubic feet	62.4	Pounds of water
Cubic feet	1,728.0	Cubic inches
Cubic feet	28,317.0	Cubic centimeters
Cubic meters	1.308	Cubic yards
Cubic meters	35.31	Cubic feet
Cubic meters	264.2	Gallons
Cubic meters	1,000.0	Liters
Cubic meters	1,057.0	Quarts (liquid)
Cubic meters	2,113.0	Pints (liquid)
Cubic meters	61,023.0	Cubic inches
Cubic meters	1,000,000.0	Cubic centimeters
Cubic inches	0.000016	Cubic meters
Cubic inches	0.0005	Bushels
Cubic inches	0.0006	Cubic feet
Cubic inches	0.0019	Pecks (dry)

Multiply	By	To Get
Cubic inches	0.0037	Gallons (dry)
Cubic inches	0.0043	Gallons (liquid)
Cubic inches	0.0149	Quarts (dry)
Cubic inches	0.0164	Liters
Cubic inches	0.0173	Quarts (liquid)
Cubic inches	0.0298	Pints (dry)
Cubic inches	0.0346	Pints (liquid)
Cubic inches	0.0361	Pounds of water
Cubic inches	0.5540	Ounces (liquid)
Cubic inches	16.3872	Cubic centimeters
Cubic yards	0.7646	Cubic meters
Cubic yards	21.71	Bushels
Cubic yards	27.0	Cubic feet
Cubic yards	202.0	Gallons (liquid)
Cubic yards	807.9	Quarts (liquid)
Cubic yards	1,616.0	Pints (liquid)
Cubic yards	7,646.0	Liters
Cubic yards	46,656.0	Cubic inches
Cups	0.25	Quarts (liquid)
Cups	0.5	Pints (liquid)
Cups	8.0	Ounces (liquid)
Cups	16.0	Tablespoons
Cups	48.0	Teaspoons
Cups	236.5	Milliliters
Feet	0.3048	Meters
Feet	0.3333	Yards
Feet	12.0	Inches
Feet	30.48	Centimeters
Feet per minute	0.01136	Miles per hour
Feet per minute	0.01667	Feet per second
Feet per minute	0.01829	Kilometers per hour
Feet per minute	0.3048	Meters per minute
Feet per minute	0.3333	Yards per minute
Feet per minute	60.0	Feet per hour
Gallons	0.00378	Cubic meters
Gallons	0.1337	Cubic feet
Gallons	3.785	Liters
Gallons	4.0	Quarts (liquid)
Gallons	8.0	Pints (liquid)
Gallons	8.337	Pounds
Gallons	128.0	Ounces (liquid)
Gallons	231.0	Cubic inches (liquid)
Gallons	269.0	Cubic inches (dry)
Gallons	3,785.0	Cubic centimeters

Multiply	By	To Get
Gallons of water	0.0038	Cubic meters
Gallons of water	0.0049	Cubic yards
Gallons of water	0.1337	Cubic feet
Gallons of water	3.7853	Kilograms
Gallons of water	8.3453	Pounds of water
Gallons of water	3,785.3446	Grams
Grains	0.0648	Grams
Grams	0.001	Kilograms
Grams	0.0022	Pounds
Grams	0.0353	Ounces
Grams	15.53	Grains
Grams	1,000.0	Milligrams
Grams per liter	10.0	Percent
Grams per liter	1,000.0	Parts per million
Hectares	2.47	Acres
Hectares	10,000.0	Square meters
Hectares	11,954.8	Square yards
Hectares	107,593.2	Square feet
Inches	0.0254	Meters
Inches	0.02778	Yards
Inches	0.08333	Feet
Inches	2.54	Centimeters
Kilograms	0.0011	Tons
Kilograms	2.205	Pounds
Kilograms	35.28	Ounces
Kilograms	1,000.0	Grams
Kilometers	0.6214	Miles
Kilometers	1,000.0	Meters
Kilometers	1,093.611	Yards
Kilometers	3,280.833	Feet
Kilometers per hour	0.6214	Miles per hour
Kilometers per hour	16.6667	Meters per minute
Kilometers per hour	18.2268	Yards per minute
Kilometers per hour	54.6806	Feet per minute
Liters	0.001	Cubic meters
Liters	0.0353	Cubic feet
Liters	0.2642	Gallons (liquid)
Liters	1.0	Kilograms of water
Liters	1.057	Quarts (liquid)
Liters	2.113	Pints (liquid)
Liters	33.8143	Ounces
Liters	61.02	Cubic inches
Liters	1,000.0	Cubic centimeters
Liters	1,000.0	Grams of water

Multiply	By	To Get
Meters	0.001	Kilometers
Meters	1.094	Yards
Meters	3.281	Feet
Meters	39.37	Inches
Meters	100.0	Centimeters
Meters	1,000.0	Millimeters
Metric tons	1.1	Tons (U.S.)
Metric tons	1,000.0	Kilograms
Metric tons	2,204.6	Pounds
Metric tons	1,000,000.0	Grams
Miles	1.6093	Kilometers
Miles	1,609.3	Meters
Miles	1,760.0	Yards
Miles	5,280.0	Feet
Miles per hour	1.467	Feet per second
Miles per hour	1.6093	Kilometers/ hour
Miles per hour	26.8217	Meters per minute
Miles per hour	29.3333	Yards per minute
Miles per hour	88.0	Feet per minute
Miles per minute	26.82	Meters per second
Miles per minute	29.333	Yards per second
Miles per minute	88.0	Feet per second
Milliliters	0.00105	Quarts (liquid)
Milliliters	0.0021	Pints (liquid)
Milliliters	0.0042	Cups (liquid)
Milliliters	0.0338	Ounces (liquid)
Milliliters	0.0676	Tablespoons
Milliliters	0.2029	Teaspoons
Milliliters	1.0	Cubic centimeters of water
Milliliters	1.0	Grams of water
Ounces (liquid)	0.00781	Gallons
Ounces (liquid)	0.03125	Quarts (liquid)
Ounces (liquid)	0.0625	Pints (liquid)
Ounces (dry)	0.0625	Pounds
Ounces (liquid)	0.125	Cups (liquid)
Ounces (liquid)	1.805	Cubic inches
Ounces (liquid)	2.0	Tablespoons
Ounces (liquid)	6.0	Teaspoons
Ounces (dry)	28.3495	Grams
Ounces (liquid)	29.573	Milliliters
Ounces (dry)	437.5	Grains
Parts / million (PPM)	0.0001	Percent
Parts per million	0.001	Liters/cubic meter
Parts per million	0.001	Grams per liter

Multiply	By	To Get
Parts per million	0.001	Milliliters per liter
Parts per million	0.013	Ounces per 100 gallons of water
Parts per million	0.0584	Grains per US gallon
Parts per million	0.3295	Gallons per acre-foot of water
Parts per million	1.0	Milligrams/ liter
Parts per million	1.0	Milligrams per kilogram
Parts per million	1.0	Milliliters per cubic meter
Parts per million	2.7181	Pounds per acre-foot of water
Parts per million	8.345	Pounds per million gallons of water
Pecks	0.25	Bushels
Pecks	8.0	Quarts (dry)
Pecks	16.0	Pints (dry)
Pecks	537.605	Cubic inches
Percent (%)	1.33	Ounces (dry) per gallon of water
Percent	8.34	Pounds per 100 gallons of water
Percent	10.00	Grams per kilogram
Percent	10.00	Grams per liter
Percent	10,000.00	Parts per million
Pints (dry)	0.0156	Bushels
Pints (dry)	0.0625	Pecks
Pints (liquid)	0.125	Gallons
Pints (liquid)	0.4735	Liters
Pints (liquid)	0.5	Quarts (liquid)
Pints (dry)	0.5	Quarts (dry)
Pints (liquid)	2.0	Cups
Pints (liquid)	16.0	Ounces (liquid)
Pints (liquid)	28.875	Cubic inches (liquid)
Pints (dry)	33.6003	Cubic inches (dry)
Pounds	0.0005	Tons
Pounds	0.4535	Kilograms
Pounds	16.0	Ounces
Pounds	453.5924	Grams
Pounds	7,000.0	Grains
Pounds of water	0.0160	Cubic feet
Pounds of water	0.1198	Gallons
Pounds of water	0.4536	Liters
Pounds of water	27.693	Cubic inches
Quarts (liquid)	0.00094	Cubic meters
Quarts (liquid)	0.0012	Cubic yards

Multiply	By	To Get
Quarts (dry)	0.03125	Bushels
Quarts (liquid)	0.0334	Cubic feet (liquid)
Quarts (dry)	0.0389	Cubic feet (dry)
Quarts (dry)	0.125	Pecks
Quarts (liquid)	0.25	Gallons (liquid)
Quarts (liquid)	0.9463	Liters
Quarts (liquid)	2.0	Pints (liquid)
Quarts (dry)	2.0	Pints (dry)
Quarts (liquid)	2.0868	Pounds of water
Quarts (liquid)	4.0	Cups
Quarts (liquid)	32.0	Ounces (liquid)
Quarts (liquid)	57.75	Cubic inches (liquid)
Quarts (dry)	67.20	Cubic inches (dry)
Square feet	0.000009	Hectares
Square feet	0.000023	Acres
Square feet	0.0929	Square meters
Square feet	0.1111	Square yards
Square feet	144.0	Square inches
Square inches	0.00064	Square meters
Square inches	0.00077	Square yards
Square inches	0.00694	Square feet
Sq. kilometers	0.3861	Square miles
Sq. kilometers	100.0	Hectares
Sq. kilometers	247.104	Acres
Sq. kilometers	1,000,000.0	Square meters
Sq. kilometers	1,195,982.7	Square yards
Sq. kilometers	10,763,865.0	Square feet
Square meters	0.0001	Hectares
Square meters	1.308	Square yards
Square meters	10.765	Square yards
Square meters	1,549.9669	Square feet
Square miles	2.5899	Square kilometers
Square miles	258.99	Hectares
Square miles	640.0	Acres
Square miles	2,589,735.5	Square meters
Square miles	3,097,600.0	Square yards
Square miles	27,878,400.0	Square feet
Square yards	0.00008	Hectares
Square yards	0.00021	Acres
Square yards	0.8361	Square meters
Square yards	9.0	Square feet
Square yards	1,296.0	Square inches
Tablespoons	0.0625	Cups
Tablespoons	0.5	Ounces
Tablespoons	3.0	Teaspoons
Tablespoons	15.0	Milliliters

Multiply	By	To Get
Teaspoons	0.0208	Cups
Teaspoons	0.1667	Ounces
Teaspoons	0.3333	Tablespoons
Teaspoons	5.0	Milliliters
Tons	0.907	Metric ton
Tons	907.1849	Kilograms

Multiply	By	To Get
Tons	2,000.0	Pounds
Tons	32,000.0	Ounces
Yards	0.000568	Miles
Yards	0.9144	Meters
Yards	3.0	Feet
Yards	36.0	Inches

APPENDIX E

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PESTICIDE EMERGENCY INFORMATION

For any type of an emergency involving a pesticide, immediately contact the following emergency information centers for assistance.

Current as of September 1997

Human Pesticide Poisoning

MICHIGAN POISON CONTROL SYSTEM

From anywhere in Michigan, call

1-800-POISON 1

1-800-764-7661

Special Pesticide Emergencies

Animal Poisoning

Your veterinarian:

_____
Phone No.

or

Animal Health Diagnostic Laboratory (Toxicology) Michigan State University:

(517) 355-0281

Pesticide Fire

Local fire department:

_____
Phone No.

and

Fire Marshal Division, Michigan State Police:
M–F: 8–12, 1–5

(517) 322-5847

Traffic Accident

Local police department or sheriff's department:

_____
Phone No.

and

Operations Division, Michigan State Police:

****(517) 336-6605***

**** Telephone Number Operated 24 Hours***

Environmental Pollution

Pollution Emergency Alerting System (PEAS), Michigan Department of Environmental Quality:

_____
District MDEQ Office Phone No.

and

For environmental emergencies:

****1-800-292-4706***

also

****1-800-405-0101***

Michigan Deparment of Agriculture Spill Response

Pesticide Disposal Information

Michigan Department of Environmental Quality. Waste Management Division.

Monday– Friday: 8 a.m.–5 p.m.

(517) 373-2730

National Pesticide Telecommunications Network

Provides advice on recognizing and managing pesticide poisoning, toxicology, general pesticide information and emergency response assistance. Funded by EPA, based at Oregon State University

Monday – Friday; excluding holidays

6:30 a.m. – 4:30 p.m. **Pacific Time Zone**

1-800-858-7378

FAX: 1-541-737-0761

Revised by Julie S. Johanningsmeier, *Pesticide Education Program, Michigan State University Extension*

▼ CUT ALONG DOTTED LINE ▼

▲ FOLD TOP FLAP IN, FOLD AGAIN AND SEAL WITH TAPE ▲

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We would like to hear from you.

Your input is valuable for making the pesticide certification training manuals appropriate for your industry.

Please take a moment to fill out this evaluation form for this manual, *General Pest Management: A Guide for Commercial Applicators, Category 7A,* and return it to the Pesticide Education Program office, Michigan State University Extension.

1. Were the learning objectives at the beginning of each chapter useful to your study of this manual?
   Yes or No

2. Did you work through the review questions at the end of each chapter? Yes or No

   If yes, did you find them helpful for preparing to take the Michigan Department of Agriculture (re)certification exam? Yes or No

3. Is there information that you believe would enhance the usefulness of this training manual that was NOT included? Please explain.

4. Were the pest management methods described in this manual typical of those used by people in your industry? Yes or No.

   If no, please explain.

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