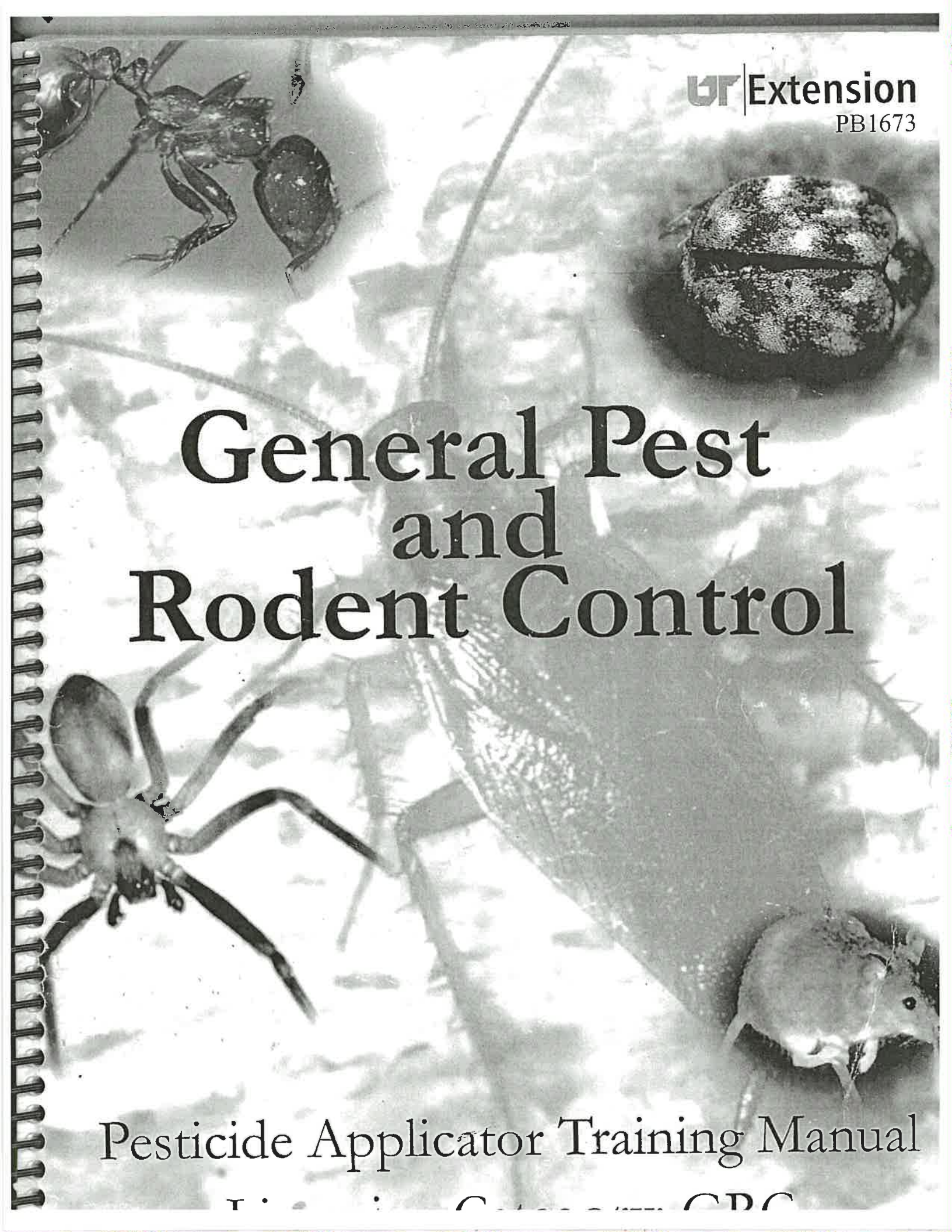


UT Extension
PB1673

General Pest and Rodent Control

Pesticide Applicator Training Manual

Table of Contents

Preface

Many living organisms can be pests in or around structures. These may be insects and related arthropods, fungi, rats, mice, bats and certain birds. Some pests, such as those that damage furnishing or fabrics, or pests that infest or contaminate stored food and other items, cause huge economic losses. A few pests spread disease organisms that can cause serious human illness. Certain types of pests inflict annoying or painful stings or bites. In addition, nuisance pests like earwigs or sowbugs are unwelcome invaders in homes and can also contaminate products or cause legal concerns in commercial areas.

Pests that damage property, injure people or affect people's quality of life need to be managed safely, effectively, and economically. Sometimes there are several ways to control pests, such as sanitation, habitat modification, trapping and pesticide use.

Pesticides can be very effective tools for controlling pests. But if you use pesticides improperly, you may injure yourself and other people and create environmental problems. In addition, some improperly used pesticides may damage treated surfaces. To prevent problems and accidents, you must always follow pesticide-label instructions and use basic common sense. This book contain important information to help you use pesticides properly in and around structures.

How to Use This Book

Use this book to make effective pest management decisions that will reduce hazards to yourself, other people and the environment. If you are preparing for the General Pest and Rodent Control (GRC) examination to obtain a pest control operator license, use this book as a study guide.

When you apply pesticide in or around structures, use this book as a reference for information on pests, pest management and pesticide use. You should find the book helpful if you supervise or train persons who handle or apply pesticides in any type of residential, industrial or institutional situation.

Shaded boxes present helpful information about pesticides and their alternatives. Many tables summarize important points in the text and give additional information.

The references at the end of this book include many well-illustrated books and pamphlets that provide additional information on identification, biology and pest management. Furthermore, you can obtain pest management information and recommendations for specific pests from the University of Tennessee Extension offices in Tennessee counties. Recommendations for specific pesticide products can be found in the UT Entomology and Plant Pathology Department's Redbook online at http://eppserver.ag.utk.edu/redbook/redbook.htm.

Chapter 1 Federal and State Pesticide Laws and Regulations

A pesticide is any substance or mixture of substances or chemicals intended for defoliating or desiccating plants or for preventing, destroying, repelling or mitigating any insects, rodents, fungi, bacteria, weeds or other forms of plant or animal life declared to be a pest. This includes, but is not limited to, insecticides, fungicides, bactericides, herbicides, desiccants, defoliants, plant regulators and nematocides.

U.S. Environmental Protection Agency

EPA is responsible for the registration of pesticides, reviewing labels for accuracy and safety, development of pesticide applicator training materials and enforcement of federal pesticide laws and regulations. Through its Office of Pesticide Programs (OPP), EPA uses FIFRA to manage its mandate.

The EPA regulates pesticides to protect humans and the environment. Enforcement of FIFRA is the responsibility of the EPA which, in turn, may, through cooperative agreements, delegate the authority for enforcing the act to states and Native American tribes. EPA has developed regulations for pesticide registration and use.

Each state and tribe has laws governing pesticides and their uses and these laws must be at least as strict as the federal laws. State certification plans are approved and evaluated by EPA. Because pesticide applicators are directly regulated and certified by their state agencies, these applicators must have a thorough knowledge of the state and federal pesticide laws.

Tennessee Application of Pesticide Act, Pest Control Operator Regulations and Regulation Governing Restricted Use Pesticides

The following pages will cover portions of the previously mentioned laws and regulations found in the "Laws and Regulations Governing Pest Control Operators and Applicators of Restricted Use Pesticides." This book may be obtained from the Tennessee Department of Agriculture (TDA), Ag Inputs and Pesticide Section of the Regulatory Services Division.

TDA is responsible for the protection of the health, safety and welfare of pest control employees and the general public from hazards and consequences of pest control activities. TDA ensures that all pesticides are used in accordance with the registered labels and labeling. The Department regulates all pesticide use within Tennessee, issues certification for uses of restricted-use pesticides, and enforces regulations dealing with pesticide safety, handling, application, and disposal. TDA certification and enforcement functions are coordinated primarily through the Ag Inputs and Pesticides Section of the Regulatory Services Division.

In Tennessee, TDA establishes qualifications and administers examinations for individuals to become commercial applicators and licensed pest control operators that enables these people to apply restricted-use pesticides and become involved in commercial pest control operations (charge a fee).

The department also certifies people as commercial applicators who do pest control work in residential, industrial or institutional buildings (and other areas) as part of their regular employment. Such people include building superintendents, caretakers and maintenance workers who are employed by apartments, schools, government agencies, manufacturing plants, private businesses, hospitals or similar facilities.

The governor appoints a seven-member pest control board to advise the Commissioner of Agriculture as to the promulgation of rules and regulations. They determine the various licensing categories, prescribe the required qualifications for applicants and approve the necessary examinations or testing procedures.

Under the Commissioner of Agriculture, the Regulatory Services Division administers examinations and issues license to individuals performing any type of structural pest control for hire, including pesticide application. The division also regulates and monitors the pest control activities of businesses and individuals.

No city, town, county or other political subdivision may adopt or continue in effect any ordinance, rule, regulation or statute regarding pesticide sale or use except as provided in Article 62-21-118(b) of the Tennessee Application of Pesticide Act and Article 43-8-115 of the Tennessee Insecticide Fungicide and Rodenticide Act.

Certification

In Tennessee certification means the commissioner of agriculture has the authority to authorize one to use, supervise the use, buy or sell restricted-use pesticides. It also means the commissioner can authorize one to issue a wood destroying insect infestation inspection report.

Registered pesticides are classified as either general-use (unclassified) or restricted-use. Applicators of restricted-use pesticides must be certified as private applicators (farmers,

greenhouse operators or nursery operators) or commercial applicators (all other certified applicators). Commercial pesticide applicators are certified to work in certain categories.

Certification of Pest Control Technicians is amended by deleting the rule in its entirety and substituting the following language so that, as amended, the rule shall read:

Certification of Commercial Pesticide Applicators Amendments (Rule 0080-6-14-.11 Effective 01-01-08)

(1) No charter holder or licensed applicator shall allow an uncertified person to apply pesticides except in accordance with this rule.
(2) Pesticides must be applied by a certified applicator or in the presence of a applicator certified in accordance with Rule 0080-6-16-.03 [Certification Requirements] in the category in which services are being provided.
(3) Commercial Pesticide Applicators who apply pesticides under the direct supervision of a licensed pest control operator must be certified in accordance with Rule 0080-6-16-.03 in the category in which services are being provided.
(4) Commercial Pesticide Applicators will be issued an individual commercial certification card and are responsible for maintaining their certification as provided in Rule 0080-6-16-.04.

In chartered companies, registered solicitors, including sales representatives, licensees and registered technicians, who work under the supervision of a licensed pest control operator, must possess a commercial certification in each category of service.

Commercial applicator certification may be issued in the following categories: C1 – Agriculture, C2 – Forest Pest Control, C3 – Ornamental and Turf, C4 – Seed Treatment, C5 – Aquatic Pest Control, C6 – Right-Of Way, C7 – Industrial, Institutional, Structural & Health Related Pest Control, C8 – Public Health Control, C10 – Demonstration, Research and Regulatory Pest Control, C11 – Wood Preservatives, C12 – Pesticide Dealer, C13 – Anti-Fouling Marine Paint, C14 – Microbial Pest Control and C16 – Sewer Line Treatment.

Recertification

A commercial applicator's certification period lasts for only three years. Everyone's certification expires on the same date. Recertification may be obtained by acquiring a specified number of points during the current certification period. Points may be awarded for attending conferences, programs, seminars, etc., that present information pertinent to the individual's certification category. The pesticide coordinator or his/her designee in the Department of Entomology and Plant Pathology (EPP) at the University of Tennessee assigns points for educational institutional programs and TDA assigns points for industry programs. A list of approved annual meetings may be obtained from the EPP department or TDA, at the following addresses:

Pesticide Coordinator
University of Tennessee
Department of Entomology & Plant Pathology
2431 Joe Johnson Dr. 205 PSB
Knoxville, Tennessee 37996-4560

Certification & Licensing Supervisor
Tennessee Department of Agriculture
Box 40627
Porter Building
Nashville, TN 37204

A list of annual meetings where recertification points may be earned is found in E&PP Info. 375. This may be obtained from the Department of Entomology and Plant Pathology at the University of Tennessee. The EPP phone number is 865-974-7138. The upcoming meetings (current workshops/seminars) may be found on the EPP Web site by way of the Internet at http://eppserver.ag.utk.edu/psep/psep.htm or from EPP.

Charter

In Tennessee a "commercial pest control operator" is a person or business entity who

(A) Engages in the custom application of pesticides
(B) Performs an inspection of real property for the purpose of issuing a wood destroying insect infestation inspection report
(C) And, who has demonstrated to the Pest Control Licensing and Advisory Board their qualifications to design and direct pest control and inspection operations

Each person, firm or corporation who wishes to engage in business as a commercial pest control operator must secure a charter from TDA in the category or categories in which they intend to do business. This authorizes the person, firm or corporation to engage in the business of commercial pest control operations. A charter is required for each office and branch office. A commercial pest control operator is required for the main or supervisory office. Once chartered, an individual may solicit or advertise his/her business. All printed advertisement must include their charter number.

Each person applying for or holding a charter is required to have

(A) A commercial pest control operator for the main or supervisory office
(B) A licensed commercial pest control operator for each category of service offered at each office or branch office. This individual may be licensed in one or more categories. Branch offices must be supervised by licensed operators
(C) A corporate surety bond of $10,000 ($50,000 for the first three years in Category 7)
(D) Minimum liability insurance for the annual period of insurance:
$250,000 for a single occurrence of liability
$500,000 for aggregate liability
(E) Errors and omissions insurance (in addition to the above liability insurance when working with the wood-destroying organisms category) for the annual period of insurance:
$100,000 for a single occurrence
$300,000 aggregate errors and omissions liability

All persons chartered are required to

(A) List with TDA the name, residence and address and secure a solicitor's registration of each salesperson or agent who is authorized to solicit business or anyone authorized to enter into a pest control contract; a licensee or registered technician is also considered to be a registered solicitor
(B) Each person chartered is required to obtain from TDA a solicitor's registration for all sales representatives or agents
(C) Registration is issued to solicitors when the following have been shown to TDA:
  (1) The prospective solicitor is an employee of the chartered firm
  (2) The prospective solicitor has written authority to solicit business for the firm and bind the firm to contracts for pest control service
  (3) When proper fees have been paid to TDA
(D) Solicitors may possess only one registration card (from one chartered company only) and be employed by only one chartered person at a time
(E) Solicitors must be certified as commercial applicators
(F) List with the department the names, residences and addresses of all employees (exclusive of clerical employees) who are engaged in the handling, transportation or application of pesticides
(G) Notify the department of any changes in employment of these employees

TDA requires that vehicles of chartered companies used in pest control work are permanently marked with the name of the company and the charter number. The size of the lettering must be at least two inches (2") tall.

Licenses

TDA issues licenses to individuals in qualified businesses to engage in commercial pest control in Tennessee. A licensed pest control operator will also supervise the certified technicians, registered solicitors, salespersons and other licensees. A licensee should maintain an active practice. If an operator is not engaged in activities of license for one year or longer their license will have to be renewed by re-examination.

License Categories Amendments. (0080-6-14-.04 Effective 01-01-08)

The substance of the license exams will be taken from study material developed by the University of Tennessee. Such material can be purchased by contacting the University of Tennessee at (865) 974-7138 or at the University's Web site at http://eppserver.ag.utk.edu/psep/psep.htm. The license categories are as follows:

(1) Agricultural - Ground Equipment (AGE) – is the control of agricultural pests by means other than fumigation. Applicants for this license must be certified in Agricultural Plant Pest Control.
(2) Aquatic Pest Control (APC) – is the control of aquatic plants and algae through the application of pesticides. Applicants for this license must be certified in Aquatic Pest Control.
(3) Bird Control (BDC) – is the control of bird pests through the use of pesticides. Applicants for this license must be certified in Industrial, Institutional, Structural and Health-Related Pest Control.
(4) Forest Pest Control (FPC) – is the control of tree pests and diseases in institutional and non-agricultural locations. Applicants for this license must be certified in Forest Pest Control.
(5) Fumigation - Soil (FUS) – is the control of agricultural pests found in the soil application of a gas. This category includes pesticides that are in a solid or liquid state when handled or applied but which turn to gas upon being dispensed. Applicants for this license must be certified in Agricultural Plant Pest Control.
(6) Fumigation - Structural (FUM) – is the control of pests by application of a gas. This category includes pesticides that are in a solid or liquid state when handled or applied but which turn to gas upon being dispensed. Applicants for this license must be certified in Industrial, Institutional, Structural and Health-Related Pest Control.
(7) General Pest and Rodent Control (GRC) – is the control of vertebrate and invertebrate pests that invade or are normally known to invade a structure, and which are not specifically covered by other categories of licenses described herein. Applicants for this license must be certified in Industrial, Institutional, Structural and Health-Related Pest Control.
(8) Horticultural - Interior (HRI) – is the control of plant pests and diseases. The category applies to residential and commercial locations, but does not include greenhouses. Applicants for this license must be certified in Ornamental and Turf Pest Control.
(9) Horticulture - Lawn and Turf (HLT) – is the control of pests and diseases of shrubs, trees, lawns and other turfgrasses. This category includes non-agricultural locations such as residential and commercial lawns and landscapes, parks and athletic fields. These pests include, but are not limited to, bagworms, grubs, moles, voles, scale insects, weeds and diseases of turf, ornamental trees and shrubs, or others similar in nature. Applicants for this license must be certified in Ornamental and Turf Pest Control.
(10) Pest Control Consultant (PCC) – is a graduate of an accredited college or university with a Bachelor's degree in the field of pest control in which consultation is offered. A license in this category does not qualify the holder to conduct pest control operations.
(11) Public Health Mosquito Control (PHMC) – is the management of mosquitoes, in all stages of their development, on public land and public waters. Applicants for this license must be certified in Public Health Pest Control.
(12) Weed Control - Right-of-Way and Industrial (WEC) – is the control of plants, whether woody or herbaceous, by the application of chemicals generally classified as herbicides, to industrial sites and rights-of-way such as, but not limited to, highways, transmission lines, drainage ditches, etc. Applicants for this license must be certified in Right-of-Way Pest Control.

(13) Wood Destroying Organisms (WDO) – is the control of termites, various wood borers, carpenter bees, carpenter ants and decay, without regard to the type or use of structure involved. Applicants for this license must be certified in Industrial, Institutional, Structural and Health-Related Pest Control.

(14) Wood Preservatives (WPC) – is the control of insects, fungi, marine borers and the effects of weather on wood products at the manufacturing or distribution stage that may damage or degrade the wood. Applicants for this license must be certified in Wood Preservation Pest Control.

(15) Special (SPC) – is the control of pests in special situations by methods not included in the other license categories listed above. These licenses may or may not require an exam in the discretion of the Board and are limited to specific pesticide uses and situations as determined by the Board.

Before taking a licensing exam, which is given in Nashville, applicants must show one or more of the following qualifications:

Qualifications of License Applicants Amendments. (Rule 0080-6-14-.01 Effective date 01-01-08)

(1) Applicants are required to have a Commercial Pesticide Applicator Certificate in the particular license category before taking a license examination as provided in Rule 0080-6-16-.03.

(2) Applicants must be at least 18 years of age and a U.S. citizen or possess a current U.S. government issued visa prior to taking the license examination.

(3) Education – Except for the license examination for Wood Destroying Organisms, applicants are qualified to take any license examination(s) based on their education, as follows:

(a) Applicants are qualified to take a license examination based on their education if they have a Bachelor's degree with a major or minor, as evidenced by an official transcript, in at least one or more of the following curricula: Agriculture, Biology, Chemistry, Forestry, Horticulture, Entomology, Plant Pathology and Plant Science or other similar degree.

(b) Applicants are qualified to take the Pest Control Consultant license examination if they are a graduate of an accredited college or university with a Bachelor's degree in the field of pest control in which the consultation is being offered. A license in this category does not qualify the holder to conduct pest control operations.

(4) Education and Experience: Applicants are qualified to take any license examination(s) based on a combination of their education and experience as follows:

(a) Applicants with a degree as set forth in 3(a) above and one (1) year of full-time work experience in Wood Destroying Organisms are qualified to take the license examination in that category.

(b) Applicants with a Masters or PhD degree in entomology that have graduated from the Tennessee Apprentice Termite Technician School are qualified to take the license examination in the category of Wood Destroying Organisms.

(c) Applicants who hold a current Horticulture, Lawn and Turf Maintenance (HLT); Horticulture Interior (HRI); Weed Control Right-of-Way and Industrial (WEC); or Agricultural - Ground Equipment (AGE) license are qualified to take the license examination in another of those four categories, provided they are certified in the license category applied for, have two or more years work experience in the license category applied for, and have at least twelve (12) college-level semester hours or twenty-four (24) Continuing Education Units (CEU) related to the license category applied for.

(d) Applicants are qualified to take the Agricultural - Ground Equipment or Horticulture - Lawn and Turf license examinations if they have twenty-four (24) months' work experience, a BA degree, a minimum of twelve (12) college-level semester hours or twenty-four (24) continuing education units (CEU) related to the categories of Agricultural - Ground Equipment or Horticulture - Lawn and Turf.

(5) Experience – Applicants who wish to take a license examination based only on experience must have been registered with the department as a pest control technician or salesperson, as provided in Tenn. Code Ann. § 62-21-109, for twenty-four (24) months of full-time work experience, or provide documentary evidence of such employment if the registration failed to occur at no fault of the applicant, or if the experience was obtained out-of-state.

Applicants are qualified to take the license examinations below as follows:

(a) Applicants with a valid Certified Crop Advisors (CCA) Certificate are qualified to take the Horticulture - Lawn and Turf (HLT) or Agricultural - Ground Equipment (AGE) examinations, provided they have satisfied the requirements above, have one (1) year of full-time work experience applying pesticide in the category of license applied for and are certified in the category of same.

(b) Applicants with a current General Pest and Rodent Control license and a Public Health Mosquito Control certificate are qualified to take the license examination in the latter category.

(6) Applicants who misrepresent their work experience shall be ineligible to take the examination for two (2) years after the applicant meets the required qualifications.

(7) If the Department determines that the application contained inaccurate information after a person passes the examination and is issued a license, the license shall be revoked in accordance with the Uniform Administrative Procedures Act, and the person shall not be allowed to resubmit an application for the license examination for two (2) years.

Certification of Qualifications Amendments. (Rule 0080-6-14-.02 Effective date 01-01-08)

Upon application to take a license examination, or at such other time as the Pest Control Board (hereinafter referred to as Board) may require, the applicant shall present:

(1) A certified statement or letter from persons or firms in whose employment the applicant received any qualifying experience; and/or

(2) A copy of a diploma, transcript, or certificate properly evidencing a qualifying degree, professional standing, course hours or continuing education units (CEUs).

Authority: Tenn. Code Ann. §§ 62-21-105 and 62-21-118.

Examination of Applicants Rule Amendment. (0080-6-14-.03 Effective date 01-01-08) is amended by deleting the rule in its entirety and substituting the following language so that, as amended, the rule shall read:

Examination of License ApplicantsAmendment. (0080-6-14-.03 Effective date 01-01-08)

(1) Applications to take a license examination shall be submitted by the tenth day of the month preceding the month of the scheduled examination.

(2) License examinations will be given the first month of each quarter at Ellington Agricultural Center in Nashville, Tennessee or when and where the Board decides.

(3) Qualified applicants who have submitted an application will be notified of the date, place and time of the examination(s). Applicants who are not qualified will be notified in writing that the application was not approved with the reason(s) stated.

(4) License examinations shall be given in two (2) parts as follows:

(a) The first part of the examination will test applicants in the following areas of competency as they apply to the specific categories of licensure:

1. State and Federal Laws & Regulations
2. Insects
3. Weeds & Disease
4. Plant Management Decision Making
5. Herbicide Technology
6. Pesticide Safety
7. Adjuvants
8. Fumigation and Soil Fumigation
9. Integrated Pest Management
10. Environmental Considerations
11. Principles of Vegetation Management
12. Plant Growth Regulators
13. Calibration of Application Equipment
14. Common Problems encountered during Application
15. Professionalism and Public Relations in Vegetation Management
16. Pest, Bird, Plant, Tree and Disease Identifications
17. Pesticides and Human Health
18. Drift Management
19. Navigation (Aerial - using GPS, DGPS, OmniSTAR)
20. Calculating area of Target Site
21. Pesticide Measurement Systems
22. Operations (Aerial - pilot & ground crews, aircraft crash response)
23. Mosquitoes & Human Diseases
24. Life cycle of Mosquitoes
25. Wood Destroying Organisms
26. Vertebrates and Invertebrates
27. Pests on or Near Food
28. Urban IPM Programs
29. Implementing Urban Pest Management Programs

(b) The second part of the examination will test applicants on specimen identification as it relates to the particular license category.

(5) To pass the license examination, applicants must score seventy (70) percent or higher on both parts.

(6) Applicants will be allowed two (2) hours to complete the first part of the examination and three (3) hours to complete the second part.

(7) While there is no limitation on the number of categories for which a license applicant may be examined during any examination period; the above-stated time limits shall apply.

(8) Applicants approved to take the license exam(s) are required to present a photo ID on the day of testing.

(9) Applicants must pass the first part of the examination before they can take the second part. Applicants that fail the second part shall only be required to retake that part of the exam.

(10) Applicants exhibiting unethical behavior during an examination shall be ineligible to take another license examination for two (2) years.

(11) Applicants who cannot take a scheduled exam due to circumstances beyond their control must contact the Department within forty-eight (48) hours of the scheduled exam to reschedule or their exam fee will be forfeited.

Whether or not engaged in the business of applying pesticides, a person may not apply a pesticide within any of the following buildings, except under the direct supervision of a person licensed to apply pesticides (chartered and non-chartered firm or business):

(A) any building used for the preparation or serving of food

(B) any building used for the temporary or permanent lodging of others

(C) any building used primarily for educational purposes, except those buildings used primarily for religious instruction or for providing education to not more than ten persons

(D) any commercial food-processing facility

These stated rules do not apply to the application of pesticides by an individual in his/her dwelling, nor to the application of pesticides by the owner of a multi-unit dwelling

in which the owner resides and which contains not more than three additional units used for the temporary or permanent lodging of others.

Licensed pest control operators should be in charge of the licensee's pest control activities. It is suggested that he/she primarily supervise the pest control activities at a business location, such as

1. Selection of proper, correct chemicals for the particular pest control work
2. Safe and proper use of these pesticides
3. Correct concentration and formulation of pesticides used
4. Training of pest control technicians in the proper and acceptable methods of pest control

   Training should include laws and rules pertaining to pest control; precautions to safeguard life, health, and property; pests (their habits, recognition of damage, and identification to common name); accepted industry practices in pest control; how to read labels; and integrated pest management.
5. Control measures and procedures used

To become a licensed pest control operator, each person must first pass the commercial certification exam. It is recommended that this exam be taken prior to the licensing category exam(s).

Individuals who wish to become licensed may obtain an application from UT's Pesticide Coordinator office (218 Plant Science Building, the University of Tennessee; phone: (865) 974-7138, fax: (865) 974-8868) or the Certification and Training Supervisor (Ag Inputs & Pesticide Section, Porter Bldg.) or write to one of the following:

Pesticide Coordinator
The University of Tennessee
Department of Entomology and Plant Pathology
2431 Joe Johnson Dr. 205 PSB
Knoxville, TN 37996

Certification and Training Supervisor
Tennessee Department of Agriculture
P.O. Box 40627
Melrose Station
Nashville, TN 37204

The application should be completed and sent to the Certification and Training Supervisor with TDA.

Licensing exams are given in January, April, July and October. Therefore, applications for exams will need to be in the Regulatory Services Division office postmarked by midnight on the tenth of the month preceding the month of the present exam (December 10, March 10, June 10 and September 10). Applications must be received with correct fees plus a college transcript or certificate of experience. The applicant will be notified by the Certification and Licensing Coordinator with the statement of "application approved." The exam fee is $150 per category for initial or re-examination.

If approved, the applicant may take the licensing exam the next month of the same quarter, when the exam is offered. The licensing exam is usually offered on Tuesday and Wednesday of the first week in the quarter. Generally, the HLT, HRI, PHMC, AGE, FUM and FUS exams are offered on Tuesday; the GRC, WDO, AQW, WEC and BDC are offered on Wednesday. Applicants for PPC and SPC appear before the board.

Applicants may study specimens when enrolled in UT Extension's licensing seminars (HLT, PHMC, GRC and WDO). Training may be offered for some licensing categories prior to the licensing exams. Call the University of Tennessee Pesticide Coordinator's office at (865) 974-7138 for more information. The exams are given only at the Ellington Agricultural Center Auditorium in Nashville. You should bring a magnifying glass with light to the exam.

Once an individual has passed the licensing category exam(s), they should then obtain a surety bond from a bonding company and liability insurance. Proof of bonding and insurance, together with an application and fee, is presented to TDA for a charter.

Denial, Suspension or Revocation of Charter, License or Certificate

If a charter holder, licensee, or certificate holder has violated any provision of the law or used any economic poison in violation of the law, a hearing may be held by TDA. The purpose of the hearing is to determine if the license, charter or certification should be denied, suspended, revoked or modified, and/or impose civil penalties of up to $1000 for each violation. A warning notice may be issued.

A charter is automatically suspended if the licensed pest control operator, whose name appears on the charter, ceases to be in charge of the charter holder's pest control operations. A grace period of 120 days may be granted so the charter holder may find another qualified operator to be examined by TDA.

A custom applicator without a valid charter is considered a Class A misdemeanor. According to the TN Code Annotated, TCA 40-35-110 & 111, the penalty for a Class A misdemeanor is imprisonment not greater than 11 months and 29 days or a fine not to exceed $2,500 or both, unless the statute states otherwise.

Fees

There are certain fees involved when becoming certified, licensed and or chartered. They are the following:

(A) Charter $400 (Paid every two years)
(B) License $40 (Paid every two years)
(C) Registration of non-clerical employees $40 (Paid every two years)
(D) Consultants license $250
(E) Licensing exams $150
(F) Re-examination fee for license $150

Charter and License Renewals

TDA has established a system of license and charter renewals at staggered intervals. Starting in 2001, those whose last names began with A thru K did not have to renew their charter and license until January 2001 and those from L thru

Z until January 2002. Then everyone went to a two-year cycle for renewal.

A 30 day grace period is allowed to renew license or charters. Following the grace period, a ten dollar per day penalty is levied for each day they are late.

Record Keeping

Record keeping Requirements for Commercial Pest Control Operators and Commercial Applicators Amendments. (0080-6-14-.12 Effective date 01-01-08)

(1) All commercial applicators and pest control operators shall keep true and accurate records of both restricted and non-restricted pesticides, retain such record for two (2) years, and make the original records and copies thereof available to the Commissioner of Agriculture, or his designee.

(2) These records must show:
- (a) The applicator name(s) and TDA-assigned ID number;
- (b) The pesticide used;
- (c) The target pest(s);
- (d) The crop, plant, house, business, or building the pesticide is applied on or to and the location thereof; including the physical address or Farm Services Agency number;
- (e) The application rate;
- (f) The percentage of mixed-use dilution;
- (g) The landowner, agent or other person employing such applicator;
- (h) The date of service, and
- (i) The amount of pesticide used.

The University of Tennessee Extension has a commercial applicator form, Form 805, which has all the requirements for record keeping and non-required recommended items. A printable record keeping form, as well as pesticide record keeping software may be downloaded at http://eppserver.ag.utk.edu/psep/psep.htm.

Tennessee Insecticide Fungicide and Rodenticide Act (TIFRA)

Sale or Transportation of Pesticides

It is unlawful for any person to distribute, sell or transport in intrastate or interstate commerce any pesticide

- (A) If it is not registered according to the law in Tennessee
- (B) If any claims or directions for use differ from its registration
- (C) If the composition differs from the composition of registration
- (D) If not in the manufacturer's unbroken, properly labeled container
- (E) If any highly toxic pesticide that does not have the skull and crossbones, with the signal word "poison" in red on a contrasting background
- (F) If an antidote for the pesticide is not listed on the label
- (G) If any pesticide is adulterated or misbranded

A violation of this section of the law is a Class C misdemeanor.

Label

It is unlawful to

- (A) Detach, alter, deface, or destroy, in whole or in part, any label or labeling
- (B) For any manufacturer, distributor, dealer, carrier, or other person to refuse information on the nature or kind of a pesticide; or, to refuse TDA representatives to have access to and to copy any records of business transactions that are essential in carrying out the law (TIFRA)
- (C) For any person to give a false guaranty as provided in the law (TIFRA)
- (D) For any person to dispose of, discard or store any pesticide or pesticide containers in a manner that would cause injury to man, vegetation, crops, livestock, wildlife, beneficial insects or to pollute any water supply or waterways

Registration of Pesticides

Every pesticide which is distributed or sold within the state must be registered with TDA and registration fees paid. All pesticide products must be registered annually and their registration expires on June 30 each year. The fee for registration is $100 for each grade or brand of pesticide to be registered. A 30 day grace period is allowed for renewals of registration, but upon any renewal following the grace period, an additional $50 late fee is charged.

The Commissioner may refuse to register or may revoke or suspend any or all registrations where the registrant is found to have violated any provision of the law (TIFRA).

Powers of the Commissioner The Commissioner is authorized to

- (A) Enter any car, warehouse, store, building, boat vessel or other place where pesticides are held for distribution or sale for the purpose of inspection or sampling for analysis or examination from any lot, package or parcel containing a pesticide
- (B) Classify pesticides for general-use or restricted-use
- (C) Periodically review the records of sales of restricted-use pesticides by licensed dealers

Stop Sale, Use, Removal, Seizure, or Condemnation The Commissioner may issue and enforce a written "stop sale, use, or removal" order to the owner or custodian of any lot of pesticide. And, this may be held at a designated place, when it is found that the pesticide is being offered for sale in violation of any of the provision of the law. It may be held until the law has been complied with and the pesticide is released by the Commissioner.

Any lot of pesticide not in compliance with the provision of TIFRA is subject to seizure. If the court finds the pesticide to be in violation of parts 1 and 2 of TIFRA and orders the condemnation of the pesticide, it will be disposed of in any manner consistent with the laws of Tennessee. The claimant may apply to the court for release of the pesticide or permission to process or relabel the product to bring it into compliance.

Pesticide Dealers

All persons offering restricted-use pesticides for sale in Tennessee must be a holder of a valid pesticide dealer license. A separate license must be obtained for each location or outlet where the business may be conducted. Each applicant for an original license must take a written examination given by TDA.

Dealers must complete an application and send it together with $50 to TDA. Dealers must submit to TDA, with each application for an original or renewal license, all persons employed by him/her who sell or solicit the sale of restricted-use pesticides. All licenses expire annually on June 30. If the application for renewal of a license is not filed on or before July 1 of any year, a penalty of $25 is assessed and added to the fee.

Licensed pesticide dealers must maintain records necessary to identify all purchases of restricted-use pesticides. The records must include the name of the purchaser, the purchaser's certification number, and the name and the amount of the pesticide purchased.

Federal Hazardous Materials Transportation Law

The Department of Transportation (DOT) is authorized under the Federal Hazardous Materials Transportation Law (formerly the Hazardous Materials Transportation Act) to regulate the shipment of hazardous materials in commerce, whether shipments are made by motor vehicle, rail car, aircraft or vessel. The Research and Special Programs Administration (RSPA) is responsible for promulgating, administering, enforcing and interpreting hazardous materials regulations. The Office of Hazardous Materials Safety (OHMS) within RSPA is in charge of writing regulations, granting exemptions, providing interpretations and enforcement. The hazardous materials transportation regulations issued by RSPA are found in 49 CFR 100-185 and apply only to hazardous materials — materials which, when offered for transportation, can pose an unreasonable risk to health, safety and property.

Before a material may be shipped domestically, it must be classified to determine whether it meets one or more of the DOT hazard class definitions. Pesticides are frequently subject to DOT regulations since the active ingredients or other components in the formulation may cause the products to meet one or more of the DOT hazard class definitions. If the pesticide is determined to be hazardous, it must be properly packaged, described and certified on shipping papers. Non-bulk packages must be marked with a DOT proper shipping name and UN/NA identification number (from 49 CFR Section 172.101) and other package markings, as required, and labeled with DOT 4" x 4" hazard labels, if specified.

In general, portable tanks, tank trucks, and tank cars which contain hazardous materials must display placards on both sides and both ends, and they must remain placarded when they contain a residue of hazardous material. Portable tanks having a rated capacity of less than 1000 gallons may be labeled on two sides, two ends, or placarded on two opposite sides. Transport vehicles, portable tanks, and freight containers that contain materials subject to the "Poison-Inhalation Hazard" shipping paper requirement must be placarded "POISON," "POISON-INHALATION HAZARD," OR POISON GAS," as appropriate on each side and end in addition to any other placards required because of additional hazards. Technical names (recognized chemical name) must also appear in parentheses as part of the non-bulk package markings. Trade names cannot be used as technical names unless they appear in the hazardous materials table. Mixtures or solutions of hazardous materials require the technical names of at least two components contributing to the hazards to be identified on both shipping papers and non-bulk package markings.

Individuals who perform functions involving the transportation of hazardous materials must receive training concerning regulatory requirements applicable to those functions. Persons who in the course of employment directly affect hazardous materials transportation safety must be trained.

The regulatory requirement is designed to increase hazmat employee awareness of safety considerations involved in loading, unloading, handling, storing, shipping paper preparation, marking, labeling, placarding, and transportation of hazardous materials, and to improve emergency preparedness for responding to transportation incidents and accidents.

A material of trade is a hazardous material carried on a motor vehicle: 1. To protect the health and safety of the driver or passengers; 2. To support the vehicle operation or maintenance; 3. By a private motor carrier in direct support of a principle business that is other than transportation.

Materials of trade must be packaged in the manufacturer's original DOT authorized packaging, or a packaging of equal or greater integrity.

Occupational Safety and Health Act

The Occupational Safety and Health Act was established to assure working people safe and healthful working conditions. It imposes upon employers the obligation to provide employees with workplaces that are free from recognized health and safety hazards, and to maintain compliance with specific OSHA standards. EPA has authority under FIFRA relating to the safety of farm workers in fields treated with pesticides, and OSHA has authority over manufacturing, formulating, and distribution operations involving worker safety in the pesticide industry.

Hazard Communication Standard

The OSHA Hazard Communication Standard (29 CFR Section 1910.1200) ensures that the hazards of all chemicals produced or imported are evaluated and that information concerning their hazards is transmitted to employers and employees. This so-called "Right-to-Know" law requires employers with employees exposed to hazardous chemicals to provide information to their employees on the hazards by means of hazard communication programs including labels,

Material Safety Data Sheets (MSDSs), training, and access to written records.

Under the Hazard Communication Standard, all containers of hazardous chemicals in, or leaving, the workplace (unless the container is used for temporary transfer purposes) must be labeled, tagged, or marked with appropriate hazard warnings and with an identity permitting it to be cross-referenced to the MSDS. All employers must assure that employees are adequately trained relative to the hazardous chemicals, in detection and protection methods, and in the labeling and MSDS system used in their workplace.

HCS does not apply to labeling of pesticides covered under FIFRA. Inert ingredients and intermediates which are not pesticides under FIFRA are covered.

Resource Conservation and Recovery Act (RCRA

The Resource Conservation and Recovery Act (RCRA) of 1976 (as amended) regulates the generation, treatment, storage, transportation, and disposal of solid wastes. Solid waste are defined as hazardous under RCRA when they are included in one of several lists. Two of these are

- P-List – Acutely hazardous commercial chemical products (40 CFR 261.33(e))
- U-List – Toxic and other commercial chemical products (40 CFR 261.33(f))

Both the P- List and the U-List contain several commercial pesticides.

The following are examples of pesticide wastes which can be regulated under RCRA:

- Discarded, unused pesticides, either as technicals or formulations, that are listed or that meet one or more of the characteristics of hazardous waste
- Discarded residue or rinsate from drums, tanks, or containers depending on the RCRA classification of the pesticide/rinsate
- Non-empty pesticide containers which held a listed pesticide or held a pesticide exhibiting a hazardous waste characteristic; in the case of pesticides that are acutely hazardous (P-List), containers or inner liners from containers are also acutely hazardous wastes when disposed unless they have been triple rinsed with an appropriate solvent
- Pesticide residue consisting of contaminated soil, water, or other debris resulting from the cleanup of a spilled pesticide

In order to know how such regulated pesticide wastes must be managed, a generator must first determine into which of the three classes it falls. The classes are

1. Conditionally Exempt Small Quantity Generator – Generators of no more than 100 kilograms (kg) of hazardous waste or 1 kg of acutely hazardous waste (P-listed commercial chemical products) per month (including no more than 100 kg of clean-up debris from cleaning up a spill of an acutely hazardous waste)
2. Small Quantity Generator – Generators of 100 to 1000 kg of hazardous waste per month that do not generate more than 1 kg of acutely hazardous waste (or 100 kg of spill clean-up debris) during the same month, and who never accumulate more than 6000 kg on-site
3. Large Quantity Generator – Generators of 1000 kg or more of hazardous waste or more than 1 kg of acutely hazardous waste per month

Small Quantity and Large Quantity Generators must notify EPA that they are a generator and must obtain an EPA Identification Number. Hazardous waste cannot be stored without an RCRA permit. However, EPA regulations allow storage in containers or tanks without a permit for specified times under certain conditions (See 40 CFR 262.34).

When wastes are stored in containers, the containers must be labeled with the words, "HAZARDOUS WASTE," and must be marked with the date on which wastes began to accumulate in that container. The containers must be kept closed, must be in good condition, and must be inspected weekly for signs of corrosion, leaks, bulges, etc.

Small Quantity Generators must either transport waste off-site, or treat them on-site, within 180 days. Large Quantity Generators must either transport wastes off-site, or treat them on-site within 90 days.

Transportation Requirements

Hazardous waste which is to be shipped must be packaged according to U.S. DOT regulations, and each container (drum, portable tank, tank truck, or tank car) used for shipping a hazardous waste must be labeled, marked, and placarded in accordance with these same rules. In addition to any required DOT markings, each container of 110 gallons or less must bear the following legend:

> **HAZARDOUS WASTE – Federal Law Prohibits Improper Disposal. If found, contact the nearest police or public safety authority or the U.S. Environmental Protection Agency.**
>
> **Generator's Name and Address**
> **Manifest Document Number**

The discarding of pesticides, residues, and rinsates is usually regulated under RCRA. However, disposal requirements for empty containers are mandated by EPA under FIFRA. These requirements are found in the container disposal instructions on the product label.

Comprehensive Environmental Response Compensation and Liability Act (CERCLA)

CERCLA gives EPA authority to enforce or to carry out cleanups of releases or threatened releases of "Hazardous Substances," pollutants, and contaminants resulting from chemical spills or from hazardous waste sites, when there is an imminent and substantial danger to public health, welfare, or the environment.

If during any 24-hour period, a designated "hazardous substance" is released into the environment (land, water or air) at or above a specific reportable quantity (RQ) for that material, CERCLA requires an immediate call to the National Response Center (800-424-8802). Section 102(b) of CERCLA establishes RQs of 1 pound for hazardous substance releases, except for those hazardous substances that have been assigned higher RQs as per Section 311 of the Clean Water Act.

Release means any spilling, leaking, emitting, discharging, injecting, escaping, leaching, dumping, or disposing into the environment. Reportable quantities may be found in section 302.4 of the Act.

EPA's regulations covering the designation of hazardous substances and their associated reportable quantities, as well as notification requirements under CERCLA, are found in 40 CFR 302. The list of hazardous substances, specified at 40 CFR 302.4, encompasses pesticides and other compounds.

Section 103 of CERCLA specifically exempts the following activities from release notification:

1. The application of pesticides registered under FIFRA when these pesticides are applied in accordance with the registered label instructions
2. The storage and handling of a registered pesticide product by an agricultural producer

Releases of pesticides that occur during handling and storage and releases that result during transportation are covered under provisions of CERCLA. The transportation provisions of the act direct the U.S. Department of Transportation (DOT) to list and regulate hazardous substances. In compliance, DOT has listed the hazardous substances in

Review Questions

1. Any substance or mixture of substances or chemicals intended for defoliating or desiccating plants or for preventing, destroying, repelling, or mitigating any insects, rodents, fungi, bacteria, weeds or other forms of plant or animal life declared to be a pest is known as a(n)
   - A. Herbicide
   - B. Natural control agent
   - C. Pesticide
   - D. Chemical

2. Who is responsible for registering pesticides, reviewing the pesticide labels and enforcing pesticide laws on the federal level?
   - A. USDA
   - B. EPA
   - C. TDA
   - D. TAPA

3. Who is responsible for regulating the state pesticide laws of Tennessee?
   - A. TDA
   - B. USDA
   - C. EPA
   - D. Local judge

4. What state agency regulates all pesticide use within Tennessee, issues certification for uses of restricted-use pesticides, and enforces regulations dealing with pesticide safety, handling, application, and disposal of pesticides?
   - A. CSREES
   - B. TDA
   - C. USDA
   - D. UTAES

5. Who establishes qualifications and administers examinations for individuals to become commercial and licensed pest control operators in order to apply restricted-use pesticides and become involved in commercial pest control operations?
   - A. UT and EPA
   - B. EPA and USDA
   - C. Tennessee Pest Control Board and UT
   - D. TDA in cooperation with the Tennessee Pest Control Board

6. Who advises the Commissioner of Agriculture on the promulgation of rules and regulations in Tennessee?
   - A. A seven member pest control board appointed by the governor
   - B. A 15 member board representing various industries
   - C. Selected board members from TDA and UT
   - D. TDA employees only

7. What are the types of applicators in Tennessee that may become legally qualified to purchase and apply restricted-use pesticides.
   - A. Private and commercial applicators
   - B. Workers and pesticide handlers
   - C. Licensed applicators and pesticide applicators
   - D. Licensed and Private applicators

8. A city, town, county or other political entity may adopt any ordinance, rule, regulation or statute regarding pesticide sale or use.
   - A. True
   - B. False

9. Which of the following is **not** always an example of a commercial applicator?
   - A. Farmer
   - B. Pest control technician
   - C. Solicitor for a chartered company
   - D. Licensed Pest Control Operator working for a chartered pest control company

10. A pest control technician applying pesticides under the supervision of a licensed pest control operator _____.
- A. must be certified or in the presence of an applicator certified
- B. must be trained as a perticide handler
- C. does not have to be certified
- D. must always be in the presence of an applicator certified

11. A farmer, greenhouse and nursery operator are classified as what type of applicator if applying pesticides on their own property?
- A. Private
- B. Commercial
- C. Licensed
- D. Classical

12. Your pesticide certification expires five (5) years from the date you are certified?
- A. True
- B. False

13. How do you earn recertification points?
- A. By enrolling in a course at UT or other university
- B. By attending any meeting related to pesticide application
- C. By attending programs which are pertinent to the individual's certification category and approved by UT or TDA for recertification points in Tennessee
- D. By earning a B.S. degree in any field of science

14. What instrument authorizes a person, firm or corporation to engage in the business of commercial pest control operations?
- A. License
- B. Charter
- C. Pesticide certification
- D. B.S. degree in some field of science or agriculture

15. Each person applying for a charter must have what type of individual for each category of service offered at each office or branch?
- A. A private applicator
- B. A commercial applicator
- C. A licensed pest control operator
- D. A solicitor

16. A person applying or holding a charter with a GRC license is required to be bonded for _____ for the first three years in Category 7, General Pest and Rodent Control.
- A. $5,000
- B. $50,000
- C. $15,000
- D. $25,000

17. What is the minimum amount of liability insurance required for a charter?
- A. $250,000 for a single occurrence of liability
  $500,000 for aggregate liability
- B. $50,000 for a single occurrence of liability
  $100,000 for aggregate liability
- C. $5,000 for a single occurrence of liability
  $10,000 for aggregate liability
- D. $500,000 for a single occurrence of liability
  $1,000,000 for aggregate liability

18. How much errors and omissions insurance is required when working with the wood destroying organisms category?
- A. $50,000 for a single occurrence
  $100,000 aggregate errors and omissions liability
- B. $100,000 for a single occurrence
  $300,000 aggregate errors and omissions liability
- C. $500,000 for a single occurrence
  1,000,000 for aggregate liability
- D. None of the above

19. All persons chartered are required to list with TDA each person authorized to enter into a pest control contract and employees engaged in handling, transporting, or applying pesticides.
- A. True
- B. False

20. TDA requires that vehicles of chartered companies used in pest control work permanently mark on the sides of the vehicles the following:
- A. Technician's name and license number
- B. Company's name and charter number
- C. Company's name and license number
- D. License category and charter number

21. Certified technicians, registered solicitors, salespersons and other licensees may be supervised by
- A. A licensed pest control operator
- B. Another certified applicator
- C. A commercial applicator
- D. A seasoned technician

22. If an operator is not engaged in pest control activities related to the license, their license will have to be renewed by re-examination, after what period of time?
- A. Six months
- B. Ninety days
- C. One year or longer
- D. Minimum of five years

23. Which of the following does not qualify an individual to take the GRC exam?

A. Bachelor's degree in a discipline related to the category
B. Registered with the department as a pest control technician or a salesperson for 24 months of full-time work experience
C. Worked as a pest control technician or salesperson for 24 months full-time out of state
D. Hold a pesticide certification card in the category of work

24. A person may **not** apply pesticides within any of these buildings, (a) where there is preparation or serving of food, (b) in a commercial food processing facility, (c) in buildings used for temporary or permanent lodging, or (d) any buildings used primarily for educational purposes (except buildings used primarily for religious instruction or providing education to not more than seven persons), except under the direct supervision of what type of applicator?

A. Certified applicator
B. Pest control operator
C. Licensed pest control operator
D. TDA inspector

25. Commercial applicators must keep records of the use of general and restricted-use pesticides for a period of

A. Two years
B. Five years
C. Five years for a highly toxic chemical and three years for all others
D. One year

26. Records of pesticide application must be made available on demand to the Commissioner of Agriculture, or his/her designee.

A. True
B. False

27. The General Pest and Rodent Control (GRC) licensing category covers which of the following pests?

A. Peach tree borers, corn ear worms and boll weevils
B. Cockroaches, ants, flies, spiders, domestic rodents and Indian meal moths
C. Tobacco hornworms, tomato hornworms and scale insects
D. Eastern tent caterpillars, ground beetles and slugs

28. A custom applicator operating without a valid charter, by law, is considered to be a _____.

A. Felony
B. Class A Misdemeanor
C. Class C Misdemeanor
D. A man (or woman) without a country

29. The licensing exams are offered during what months the year?

A. March, June, September, and December
B. January, April, July and October
C. Any month during a quarter, but at least quarterly
D. Randomly, at the discretion of the Board

30. The "Right-to-Know" law requires employers with employees exposed to hazardous chemicals to provide information to their employees on the hazards by means of hazard communication programs including

A. Labels, MSDS, training, access to written records
B. Labels only
C. Labels and MSDS
D. Labels, MSDS and written records

31. Under the Hazard Communication Standard, all containers of hazardous chemicals in, or leaving, the workplace (unless the container is used for temporary transfer purposes) must be

A. Labeled and marked with hazard warnings
B. Labeled and reference to the MSDS
C. Labeled only
D. Labeled, tagged, or marked with appropriate hazard warnings and with an identity permitting it to be cross-referenced to the MSDS

32. The Department of Transportation (DOT) is authorized to regulate

A. The use of pesticides on food products
B. The transportation of pesticides on the farm
C. The shipment of hazardous materials in commerce
D. None of the above

33. The hazmat employee training requirement is designed to increase the employee awareness of safety considerations involved in

A. Loading, unloading, handling, storing and shipping paper preparation
B. Marking, labeling, placarding and transporting of hazardous materials
C. Improving emergency preparedness for responding to transportation incidents and accidents
D. All of the above

34. An application for a licensing exam must be completed and sent to the Certification and Training Supervisor with TDA. This must arrive at TDA how long before the licensing exam?

A. 90 days before the exam
B. 60 days before the exam
C. By the 15th of the month preceding the month of the exam
D. By the 10th of the month preceding the month of the exam

35. It is unlawful for any person to distribute, sell or transport in intrastate or interstate commerce any pesticide that does not meet the following qualification(s):

A. Must be registered according to Tennessee laws
B. Must be in manufacturer's unbroken, properly labeled container
C. Must not be a pesticide that is adulterated or mis-branded
D. All of the above, plus more

36. It is unlawful to detach, alter, deface or destroy a label or labeling. It is also unlawful to dispose or store pesticides in a manner that would cause injury to man or the environment. These practices are essential in carrying out which law?

A. TAPA
B. FQPA
C. TIFRA
D. TN Laws and Regulations Governing Restricted-Use Pesticides

37. If during any 24 hour period, a "hazardous substance" is released into the environment (land, water or air) at or above the specific reportable quantity (RQ), CERCLA requires an immediate call to what agency?

A. TDA
B. National Response Center
C. CHEMTREC
D. National Pest Control Association

Answers: 1. C, 2. B, 3. A, 4. B, 5. D, 6. A, 7. A, 8. B, 9. A, 10. A, 11. A, 12. B, 13. C, 14. B, 15. C, 16. B, 17. A, 18. B, 19. A, 20. B, 21. A, 22. C, 23. D, 24. C, 25. A, 26. A, 27. B, 28. B, 29. B, 30. A, 31. D, 32. C, 33. D, 34. D, 35. D, 36. C, 37. B.

Chapter 2 Pest Management

Pest control involves the safe prevention, reduction or elimination of unwanted organisms. To do this, you must learn about the habits and life cycles of many pests and understand the conditions that affect pest populations. A good pest control program follows the principles of integrated pest management (IPM).

One important IPM practice commonly used around structures is pest-problem prevention. Managing pests through prevention is usually less expensive than trying to control an established pest population. Furthermore, pest prevention reduces the chance for substantial economic loss or irreversible damage. Prevention avoids some of the disruption associated with control efforts that may be needed after pests become established.

Once a pest becomes established, the most common management goal is elimination. This can only be successful if the conditions that originally favored the establishment of the pest can be modified or if entry of the pest into the area can be completely blocked.

Integrated Pest Management

IPM is an ecological approach to managing weeds, insects, vertebrates and other pest organisms that often provides economical, long-term protection from pest damage. IPM has been very successful in commercial agricultural situations and the benefits of IPM are becoming more widely recognized in the management of urban pest problems.

Pests must be found through inspection and monitoring, properly identified and aspects of their life cycle and developmental stages understood. Conditions that promote or support the pest are identified so they can be either eliminated or suppressed.

Management methods must be appropriate to the life cycle and development stages of the pest. Usually, two or more management methods are used, and commonly different methods are used at other times or in different locations, rather than using the same method for the same pest at all times. Control methods that might be used in an IPM program include exclusion, sanitation, modifying or eliminating habitats, biological control and the selective use of pesticides.

Pesticides usually play an important role in an IPM program. However, pesticides are selected carefully and are nearly always combined with other control methods.

- The timing of the pesticide application is especially important. Pesticides are selected to be least disruptive to natural controls that may be present.
- Environmental concerns and human and animal safety are an utmost priority.
- Sometimes emphasis is placed on spot treatment or reduced rates of the pesticide so that smaller quantities of pesticide can be applied.

An important component of an IPM program involves frequent evaluation of the control strategies and modification of the approach to keep pace with changes or anticipated changes in the pest's activities.

School Integrated Pest Management: A Special IPM Case

Integrated Pest Management (IPM) aims to reduce and balance risks associated with pests and pesticides. IPM emphasizes regular inspecting and monitoring of pests to detect them at low population levels. This is a better alternative than the scheduled spraying of pesticides. Information about the life cycle of the pest and its interactions with the environment are used to make a control decision. Most pests need access to food, water and shelter. By removing the basic survival elements or by blocking access into a structure, pest populations can be lowered or prevented from establishing.

Blocking access into the structure may be as easy as shutting doors when not in use; adding weather-stripping so doors close tightly; caulking and sealing openings in walls, especially around plumbing penetrations and wall/floor interfaces; installing or repairing screens; and pulling vegetation, shrubs and wood mulch at least 12-18 inches away from a structure to discourage occasional invaders as well as carpenter ants, termites and other pest species. Traps and vacuums are other less toxic tools that can be used to manage pests.

Pesticides may be necessary in an IPM program, but they should be used in a manner to minimize the risk of exposure to the occupants. The use of baits, dusts in wall voids and sprays applied in cracks and crevices should reduce exposure of pesticides to occupants.

The Tennessee Department of Agriculture (62-21-124 - Pesticides in buildings used for food preparation and service, or lodging) requires any person applying pesticides in a school to have a pesticide applicator's license or be under the direct supervision of a person licensed to apply pesticides. Therefore, teachers or other occupants cannot bring or use pesticides inside schools unless they are under the supervision

of a licensed operator. Permission by the officially designated IPM coordinator may also be required.

The following is also strongly suggested as part of the school IPM program:

- students, staff and parents should have access to a logbook that contains pesticide application records and other pest control services and information, including copies of labels and Material Safety Data Sheets (MSDS) used at each school;
- pest control services, including pesticide applications, should be recorded in a logbook prior to the next occupation of the building (before school starts the next day);
- this logbook should be kept in a central area that is easily accessible in each school;
- an overseer of the logbook should be appointed in each school;
- a waiting interval between pesticide application and student occupation of treated facilities should be decided upon and adhered to;
- pesticide applicators should be educated and trained in the principles and practices of IPM and the use of pesticides approved for use in the school system; and
- all applicators must comply with the IPM policy and follow appropriate regulations and label precautions when using pesticides in or around school facilities.

For more information on school IPM, see Extension PB1603, Suggested Guidelines for Managing Pests in Tennessee's Schools: Adopting Integrated Pest Management, available from your county Extension office or Tennessee Extension's Web site (http://www.utextension.utk.edu.)

The University of Tennessee has two Web sites related to IPM in child-serving facilities, the UT Youth, Environment and Health (UTYEAH) Research Team (http://utyeah.utk.edu) and UT Entomology and Plant Pathology School IPM area of expertise, http://eppserver.ag.utk.edu/sch_ipm.htm. The University of Florida hosts a national Web site devoted to school IPM (http://schoolipm.ifas.ufl.edu).

Locating and Monitoring Pests

Decisions to use pesticides and other control methods should be based in part on pest detection and monitoring results. Visual inspection of an area where pests or their damage occur is the most common detection method. Inspection involves careful and thorough searching in and around a structure for signs of the pest and conditions that favor pest buildup. Monitoring is a systematic method of observing pests or pest signs over time. Monitoring may help detect unwanted pests and determine from where pests are coming and where they are living. Monitoring is also helpful in evaluating control programs. Special devices and tools are available to detect and monitor certain pests.

Visual Inspection

The purpose of a visual inspection is to search for pest evidence. During an inspection, look for: (1) conditions such as food, shelter, access and suitable environments that favor pests; (2) signs of pest damage, entry or presence (such as tracks, trails, droppings, nests, and cast skins); and (3) the pest itself.

When you make an inspection, you may find it helpful to prepare sketches of the structure (or use the fire evacuation plans) and surrounding areas (Figure 2-1). Include locations of heating or air conditioning ducts and vents, plumbing inlets, attic, basement and crawl space vents, wall and sub-cabinet voids and other features of the building that allow pests to enter or that provide shelter for them. Also, observe conditions that may cause problems during pest-control operations. Be sure to note areas of poor or faulty construction or places where the building has been damaged by the careless operation of equipment, plumbing leaks or other reasons. Also, note areas that you were unable to inspect because they were inaccessible. Show the locations of trees, shrubs, trash

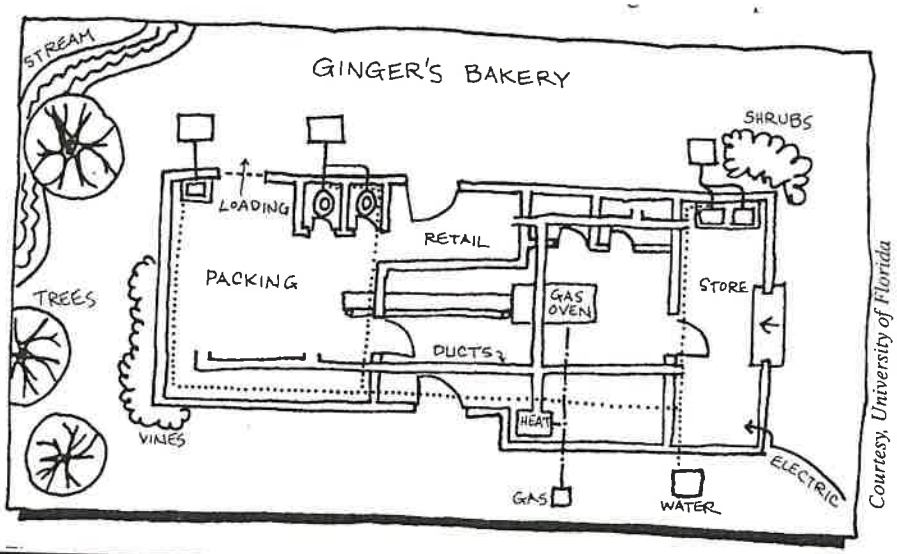


Figure 2-1. Prepare a diagram of the structure and surrounding areas, as shown here, while inspecting for pests and pest damage. Indicate the locations of doors, windows, utilities, ducting and any other areas that will require special care or attention.

Figure 2-2. Pheromone traps are available to trap cockroaches

and garbage storage, water sources and other features of the surrounding area that may attract or harbor pests or promote pest buildup.

Detection and Monitoring Devices

Several simple devices can assist you in detecting and monitoring many of the pests found in structures. Devices include pheromones and other attractants, light traps, flypaper, spring traps, glue boards and nontoxic tracking powder.

Pheromones and Other Attractants Pheromones are chemicals normally produced by certain insects (and other animals) to affect the behavior of individuals of the same species. Pheromones are used by insects for mating, aggregation, feeding, trail following and recruitment. Synthetically made pheromones mimic the action of pheromones produced by some pest insects. These are useful for monitoring the adult forms of pest moths (almond, angoumois, Indian meal, Mediterranean flour, raisin, tobacco); certain beetles (cigarette, confused and red flour, drugstore, khapra, lesser

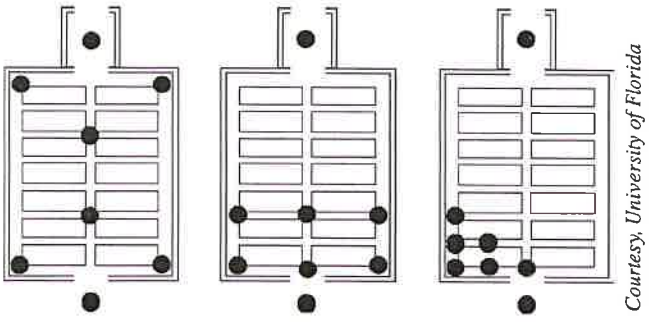


Figure 2-3. One way of using pheromone traps in a building such as a warehouse is shown here. Distribute traps throughout the building (left). Then move traps that caught few or no target pests closer to the traps where catches were high (center). Repeat this process several days later to pinpoint the source of the infestation (right). Keep a trap near each entrance at all times.

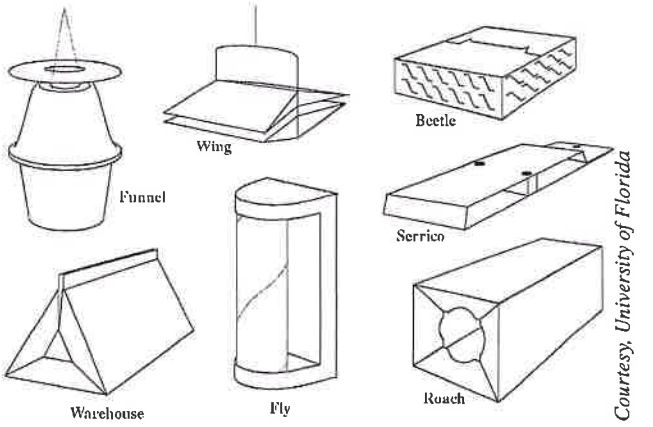


Figure 2-4. Several styles of traps are available, depending on the type of pest and type of location to be monitored.

grain borer, sawtoothed grain, and warehouse) and weevils, and some species of flies (fruit, house). Cockroaches can also be detected with pheromone traps (Figure 2-2). Certain other materials are also used as trap attractants. For example, ammonium carbonate attracts many different species of flies; food-like odors attract certain insects or rodents.

The effectiveness of attractant traps inside buildings is influenced by the number used and their locations. Figure 2-3 shows a typical placement of pheromone traps for monitoring stored-product insects. In small areas, use one trap for each 250 to 500 square feet of storage space. Larger areas, such as warehouses, require one trap to every 1,000 to 2,000 square feet. Keep traps away from doors, windows or bright lights, which may repel the target insects. Trap design (Figure 2-4) can affect the results of the trapping program—some styles appear to work better with certain species of insects. Check the supplier's recommendations for the most effective trap style. Also, choose a style based on the location where traps will be used; "wing" traps hung overhead, for instance, hide trapped insects from the public's view.

Check traps regularly. For insects, check traps a minimum of once or twice per week and remove all insects. Rodent traps must be checked every day. Clean or replace sticky surfaces whenever they become covered with debris. Replace pheromone lures periodically because they lose their effectiveness

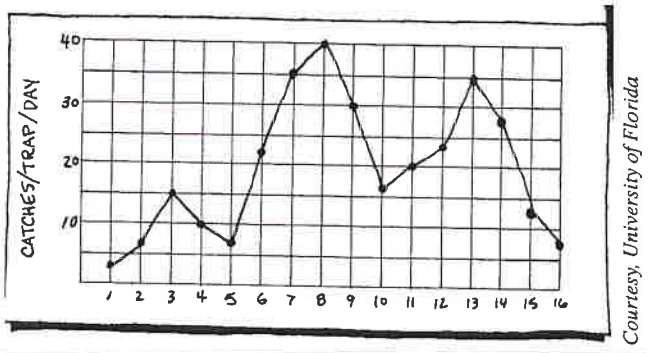


Figure 2-5. A simple graph like this can help visualize the periods of peak activity of insects being monitored with pheromone traps.

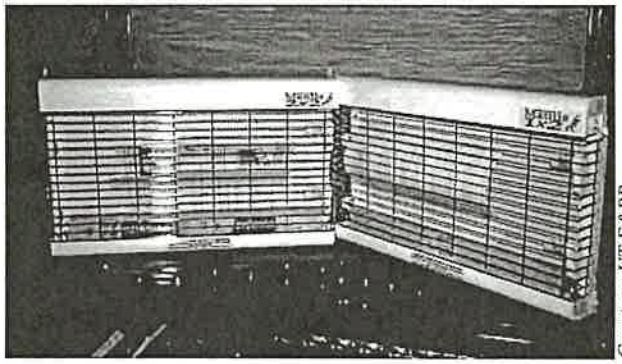

Courtesy, UT E&PP

Figure 2-6. Traps equipped with ultraviolet or "black" lights attract some species of flying insects. These traps are most effective in enclosed areas, usually at night.

over time. Consult the manufacturer's guidelines for the effective duration of the attractant used.

Record the number of target insects removed from traps each time they are checked. Plot trap catches on a per-day basis, using a simple graph like the one in Figure 2-5. This will allow you to track changes in the insect's activity and verify the success of control measures. Compare this activity with that in traps in other locations.

Light Traps — Traps (Figure 2-6) equipped with ultraviolet lights, or black lights, attract several species of flying insects. Some of these traps have a container with a funnel-shaped entrance that allows insects to enter easily but blocks their escape. Some light traps have an electrically charged grid that kills insects as they approach the light. Stun grids knock insects onto a sticky surface in some light traps. Electrocuting traps are usually not used for insect monitoring. An electric light and a sticky board are all that is used to capture flying insects in other light traps.

Use light traps inside warehouses, grocery stores and other enclosed areas for monitoring adult stages of flies, some species of fruit flies and some stored-product insects such as Indian meal moths and almond moths. Light traps are not effective for outdoor insect control.

In a large building, use one blacklight trap for every 1,000 square feet of floor space. Locate traps so the light is visible from all directions, but avoid placing them near windows or doors where the light may attract insects from outside. For monitoring stored-product insects, put traps in areas of the building where pest insects are most likely to be found—usually near a food source—but keep traps at least 5 feet away from food preparation or processing areas. Keep traps low if you are attempting to attract day-flying insects such as house flies; in this case, traps should be no more than 5 feet above the floor.

Clean blacklight traps at least once a week to prevent dead insects from becoming food for carpet or other dermestid beetles. Record the number and identity of the insects removed from the traps. Use this information to determine locations of greatest infestation and to detect cycles of pest outbreak. This information will also help you evaluate control efforts.


Courtesy, UT E&PP

Figure 2-7. Fly paper can be used for monitoring flies in confined areas.

Courtesy, UT E&PP

Figure 2-8. Glue boards can be used to control or monitor insects and small rodents. They lose their effectiveness if the sticky substance becomes coated with dust or debris.

Blacklights are less effective in bright sunlight or where other lights are being used. Also, the ultraviolet tubes used in light traps gradually lose their attractiveness to insects over time. Tubes should be replaced once a year.

Flypaper — You can use flypaper for monitoring flies within confined areas (Figure 2-7) . Some manufacturers add a fly pheromone to the sticky coating to make it more effective.

Space several flypaper traps evenly throughout areas being monitored to find out where flies are concentrated. Do not use flypaper in dusty areas because accumulated dust will clog the sticky surface and prevent flies from sticking. Flypaper traps are unsightly, so locate them out of the public's view. Check and replace traps frequently. Examine the captured insects

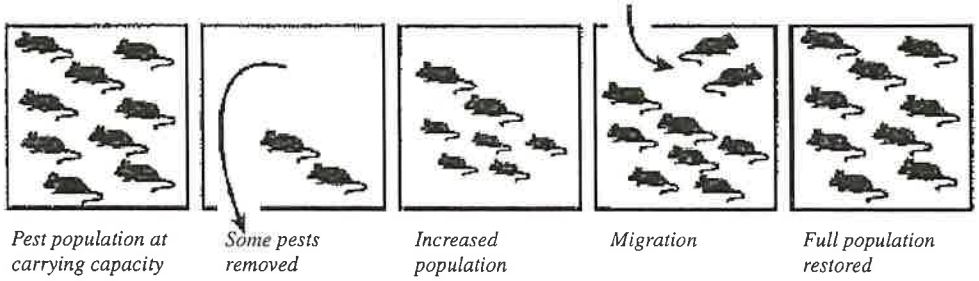


Figure 2-9. Populations of pests tend to remain fixed in size due to the carrying capacity of an area. In a building, for example, the carrying capacity is restricted by space, food and water. If individuals are removed by some pest control method, the populations may soon return to its original size as remaining individuals increase reproduction or as new individuals migrate into the area.

to determine their identity. Keep records of the numbers and species of pests caught and use this information for selecting and evaluating control methods.

Glue Boards and Traps — Glue boards are useful for monitoring crawling insects, mice and, in some instances, rats (Figure 2-8). Glue boards are sometimes used to locate areas where cockroaches congregate. By examining individuals caught on the sticky surface, you should be able to identify the species and perhaps determine areas of heavy infestations. Glue boards may also enable you to identify other types of insect pests within a confined area. Glue boards become ineffective when they are coated with dust, debris or moisture.

For monitoring cockroaches, place glue boards along travelways next to intersections of walls and floors.

To monitor rodent activity, set glue boards along known runways and near areas believed to be nesting sites. Be sure to check the traps daily and dispose of any in which a rodent has been caught.

Mice and rats can also be monitored with spring-type or multiple-catch traps. Place traps along runways and near nesting areas. Check these daily and remove captured rodents. Traps are most effective when they are baited with a substance that attracts rodents.

Nontoxic Tracking Powder — Nontoxic tracking powders are fine dusts that provide a visual record of rodent or insect activity. Nontoxic tracking powder offers an alternative to glue boards and spring traps, which must be checked daily. Powders are also a safe way to evaluate the success of a control program.

Commercial tracking powders are available that fluoresce under ultraviolet light, or talcum or baby powder can be used for tracking pests, making it easier to locate pest trails. Avoid using any powders where they might contaminate food.

Spread a thin layer of tracking powder evenly over surfaces where pests are known or suspected to occur. For easy cleanup when monitoring is completed, spread the tracking powder on sheets of paper. Look for tracks left in the powder as evidence of pest activity. Sometimes a trail of the powder leads to nests or hiding places.

Blacklights — Blacklights can be used to identify areas of rodent activity. Rodent urine will fluoresce under a blacklight. Also, scorpions can be easily located by the use of a blacklight, because they also fluoresce.

Establishing Action Thresholds

Pest control decisions are influenced by health or safety dangers created by the pest, legal restrictions on pest infestation and pest-tolerance levels. Occasionally, a pest control decision depends on the costs to control a pest weighed against the benefits. On the basis of any of these factors, an action threshold can usually be established to determine the type of control and when it should begin.

Health and Safety Thresholds

Health or safety threats commonly require fast, extensive and sometimes costly pest control measures. Several pests associated with structures, stored food products, food preparation facilities, hospitals and other areas have the potential for causing injuries to people (mosquitoes, biting bugs, fleas, spiders, bees and wasps, for example) or transmitting disease organisms to people or animals (rats and mice, cockroaches, fleas, flies and mosquitoes). Some others, such as rodents, fungi, termites and wood-boring beetles, cause damage that makes structures unsafe or reduces their value.

Decisions to control pests are based on knowledge of their potential harm. If serious injury or damage may result, the control threshold must be very low. For instance, one rat chewing on electrical wiring can cause a serious fire.

Legal Thresholds

Health codes, marketing orders and other regulations set limits on the amount of pest damage or contamination allowed in food products for sale or transport. Public safety codes often require control of pests in public buildings, commercial housing, food service facilities and other public structures. Building and safety standards address the control of structural pests as well as the repair of damage they cause. These legal thresholds dictate when pest control methods must be used, even though in some cases control methods cannot be economically justified or the pests may not be a hazard to public health or safety.

For information on laws that regulate pest infestation in certain buildings and on foods, contact state and local health departments and housing and community development offices. The Tennessee Department of Agriculture, Division of Regulatory Services has information on laws that apply to the control of structural pests. Federal marketing orders list

the allowable tolerances of specific pests or pest damage in fresh and stored food items. This information can be obtained from the U.S. Food and Drug Administration, Food Defect Action Levels.

Pest Acceptance Threshold

People have different degrees of acceptance of pests in their homes and workplaces. Pest acceptance thresholds may be high because of social or cultural factors or because of concerns about the costs or hazards of pest control methods used. A pest acceptance threshold can be very low due to a person's revulsion or fear of the pest. Acceptance thresholds may sometimes be modified if you can provide factual information about specific pests, pest damage potential and pest control methods.

Economic Threshold

In certain instances, the cost of control measures may need to be justified. Economic thresholds may apply if there are no health and safety, legal or tolerance thresholds that need to be considered. An economic threshold is a level of pest abundance at which the potential loss caused by damage is expected to be greater than the cost of controlling the pest.

Pest Control Methods

Pests can be prevented through physical control such as sanitation and habitat modification, or they can be controlled by trapping, pesticide use and, in some instances, biological control. Pests in structures are usually more effectively controlled by using a combination of compatible control methods.

Sanitation and Habitat Modification

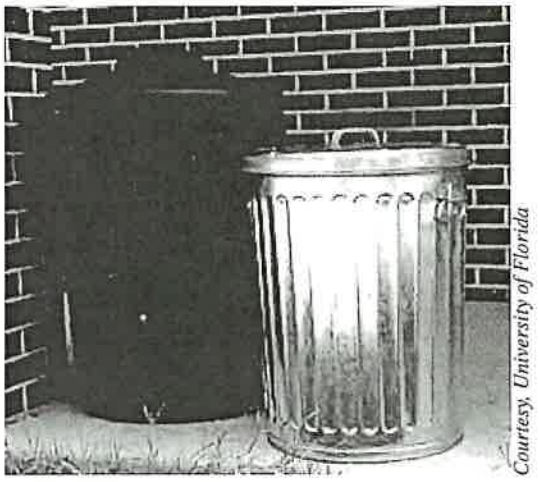
Habitats are areas within the larger environment that are suitable for a pest's survival. Habitats provide a pest with some or all of its necessary living requirements, such as food, water, shelter, optimum temperatures and humidity, and protection from enemies. A habitat can only accommodate a maximum number of pests due to limitations of one or more of these requirements. This maximum number is known as the carrying capacity.

Where large quantities of food are available and shelter and other requirements are ample, the carrying capacity is high. Such a habitat can support an almost unlimited number of individuals of a pest species. If the carrying capacity is limited, however, the population tends to remain fixed in size. If you remove individuals from a habitat through pest control measures or if they die off due to natural causes, they will be replaced soon by others, unless the carrying capacity is reduced at the same time. Population size easily returns to the carrying capacity by increased reproduction among remaining individuals or by new individuals migrating in (Figure 2-9). Table 2-1 lists ways that modifying a habitat lowers its carrying capacity.

Habitat modification usually involves improving sanitation, including removal of food, water, breeding sites and shelter used by pests (Figure 2-10). Outdoors, you may need to trim or remove dense, pest-harboring vegetation near buildings, clean up trash, keep garbage in closed containers, provide for drainage of standing water, clean up animal wastes and spilled animal feed, and eliminate items that attract pests. Inside, sanitation includes storing foods and food wastes in tightly closed containers, cleaning up spills and residues, removing trash and other materials that may be used for nests, and vacuuming and dusting regularly and thoroughly. The cleaning of surfaces may also improve the effectiveness of pesticides by removing grease, oils, dust and other contaminants that interfere with their function. To assist in good sanitation, make sure interior areas are well lighted to simplify cleaning and easy detection of pests and pest damage. Sweepings and other wastes should be taken to a disposal area outside of the building.

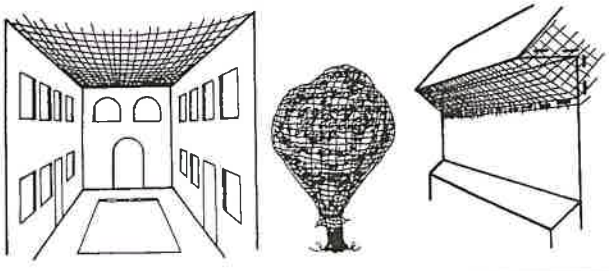
Other sanitation practices include removing dirt mounds, wood pieces and other cellulose debris from areas beneath buildings to keep from promoting termite or rodent problems. To protect against fungi, never leave unprotected wood in contact with soil or other moisture sources such as leaking pipes or faulty drains. To reduce moisture, provide adequate ventilation and a moisture barrier to areas beneath buildings.

Outdoor lights placed near entrances to buildings attract many flying and crawling insects at night. If possible, locate light fixtures away from entrances. Otherwise, modify the type of light being used. Sodium vapor lights are better



Courtesy, University of Florida

Figure 2-10. Sanitation practices are helpful in reducing pest problems because good sanitation restrict's the pest's access to food, water or shelter.



Courtesy, University of Florida

Figure 2-11. Various methods can be used to keep birds from roosting or building nests on buildings. Netting is helpful in excluding birds from trees or courtyards.

Modification	Effect on Pests
Caulk cracks in cabinets, moldings and other areas.	Reduces the amount of hiding and nesting places available for cockroaches and certain fabric pests. Excludes ants and other crawling insects.
Seal food in pest-proof containers or place in refrigerator or freezer.	Eliminates access to sources of food for cockroaches, ants, stored-product pests, flour beetles, rats and mice.
Increase light and ventilation.	Makes area unsuitable for fungi and molds, subterranean termites, flea larvae, and other insects such as cockroaches and silverfish by reducing moisture. Reduces condensation, which can be a water source for many different pests.
Reglue loose wallpaper, patch peeling plaster or paint.	Reduces hiding and nesting sites for cockroaches and silverfish.
Remodel to eliminate false bottoms in cabinets and other structural voids or blow sorptive powder into wall voids, beneath cabinets, and in other inaccessible areas.	Eliminates hiding places for cockroaches, rats, mice, spiders, silverfish, firebrats and other pests.
Insulate water pipes (seal well to prevent insulation from being a habitat for cockroaches).	Prevents condensation, which provides free water for some pests.
Store food wastes in tightly closed containers; remove from building frequently and clean containers.	Eliminates food sources for fruit flies, cockroaches, flies, mice and rats.
Clean up food or liquid spills quickly.	Prevents attracting flies, fruit flies, cockroaches, rats and mice.
Thoroughly clean food preparation and eating areas at least daily.	Eliminates food sources for fruit flies, cockroaches, flies, rodents and other pests.
Launder or dry clean clothing and linens before storage; seal in heavy plastic.	Reduces problems with fabric pests.
Blow sorptive powder into wall voids, beneath cabinets and in other inaccessible areas.	Denies hiding places for cockroaches due to its repellency.

Table 2-1. How to modify habitat to lower the carrying capacity for certain pests.

than mercury vapor lights or standard incandescent lights for outdoor use because they emit a spectrum of light that is less attractive to insects; yellow "bug" bulbs work on the same principle.

Birds can become pests when they use outside surfaces of buildings for roosting or nesting. Birds generally prefer flat surfaces that offer protection from wind, rain and extreme temperatures. To prevent birds from roosting or nesting, use plastic or wire mesh screening, cloth netting or metal flashing. You can also modify flat surfaces or overhangs to make them unsuitable for birds (Figure 2-11). The ultimate decision on how best to deal with pest birds usually depends on the species causing problems, its location on the building and the building's physical features.

A program of sanitation and habitat modification requires cooperation between pest-control specialists, building owners and inhabitants, housekeeping staff, and building and landscape maintenance workers. It is necessary that everyone understand how these practices influence pest problems (Table 2-2). People living or working in a building must keep food, food waste and trash in pest proof containers and store other items in designated places where they cannot attract pests. Inhabitants should promptly report pest problems. Housekeeping and landscape maintenance workers can help by keeping interior and exterior areas free of trash, nesting sites and other items that might be attractive to pests. They should provide containers for wastes and specify locations for storage of other materials. Buildings must be monitored

	Shelter	Animal Wastes	Debris or Clutter	Firewood	Garbage	Flours/Grains/Cereals	Cardboard/Newspapers	Vines/Shrubbery	Soiled Clothing	Spiderwebs	Spoiled Fruits/Vegetables	Stored Linens	Sugar/Sweets	Moisture or Free Water	Weeds	Sawdust/Wood Scraps	Humans, Dogs, Cats, Other Pets	Structural Lumber	Furniture/Cabinets
Ants		●			●			●			●		●	●					
Bats	●																		
Bees					●						●		●	●					
Birds	●					●		●						●	●				
Biting bugs	●		●																
Carpenter ants	●			●									●	●		●		●	
Carpenter bees	●			●															
Carpet beetles							●		●	●		●							●
Clothes moths									●			●							
Cockroaches	●	●			●	●	●	●			●	●	●	●					●
Decay fungi														●					
Firebrats	●		●				●	●				●		●					●
Fleas	●														●		●		
Flies		●			●						●		●				●		
Flour beetles						●													
Fruit flies					●						●		●						
Grain moths						●													
Granary weevils						●													
Mice	●	●		●	●	●	●	●			●		●	●	●				
Mites		●	●			●											●		
Rats	●	●		●	●	●	●	●			●		●	●	●		●		
Silverfish	●		●				●	●				●		●					●
Spiders	●			●			●	●							●				●
Termites	●	●		●			●							●		●		●	
Ticks								●							●		●		
Wasps	●	●			●			●			●		●	●					
Wood-boring beetles				●										●		●		●	●

Table 2-2. Factors that contribute to pest problems in and around buildings.

Material	Specifications	Uses	Pests excluded
Bird netting	1/4 inch plastic or cloth	Under eaves, around roof openings	Birds, bats
Brick	Most have strong mortar seams	Protective barrier for structural wood	Rats, mice, most insects
Caulking	Architectural grade, must be flexible, silicone type works best	Fill cracks and small holes in wood, masonry, and plaster	Ants, cockroaches, bats, spiders, carpenter ants, wasps
Concrete	1:2:4 mixture; aggregate 3/8 inch or smaller; add water to a wet sand consistency	Patch holes in walls or construct barriers	Rats, mice, insects
Door sweeps	Metal, leaving less then 1/4 inch gap at bottom of door	Close gaps at bottom of doors	Rats, mice, bats
Duct tape	Heavy duty	Temporary seal for large cracks, holes, seams	Bats, some insects
Expanded metal	Heavy gauge galvanized metal or aluminum, mesh less than ¼ inch	Cover vents, large openings	Rats, mice, bats
Glass jars	Must have screw-on metal lids, or tight-fitting plastic lids; jars with rubber seals and snap caps work best	Store small quantities of dried foods, sugar, syrup, honey	Stored-food pests, ants, wasps (outdoors), mice, rats
Hardware cloth	1/4 inch mesh or smaller, 19 gauge galvanized metal	Ventilators, louvers, large openings, vents	Mice, rats, bats, birds
Insulation	Roll or blow-in type	Attics, wall voids	Bats
Metal grills	Heavy gauge galvanized metal or aluminum, slots should be 1/4 inch in width or smaller	Cover vents, large openings	Rats, mice, bats
Metal sheeting or flashing	19 gauge galvanized metal or 22 gauge aluminum	Roof valleys, construction joints, opening and holes in wall or roofs, or covering or exposed wood surfaces	Mice, rats, bats
Metal threshold	Must seal with bottom of door	Closes gaps at door bottom	Rats, mice, ants, cockroaches, spiders, most other crawling insects
Mortar	1:3 mixture	Fill cracks in masonry and concrete	Rats, mice, crawling insects
Perforated metal	Heavy gauge galvanized metal or aluminum; openings should be 1/4 inch in width or smaller	Cover vents, large openings	Rats, mice, bats
Plastic bags	Heavy duty type (must be sealed well)	Store linens, woolens, cereals, sugar, flour, other dried foods and sugary foods	Clothes moths, carpet beetles, ants, cockroaches
Plastic containers	Must have tight-fitting lids	Store quantities of dried foods, nuts, grains, sugar, syrup, honey	Stored food pest, ants
Putty	Non-shrinking, weatherproof; silicone type works best	Fill cracks and small holes in wood, masonry, and plaster	Ants, cockroaches, spiders, wasps

Table 2-3. Materials used for excluding pests and repairing openings in structures.

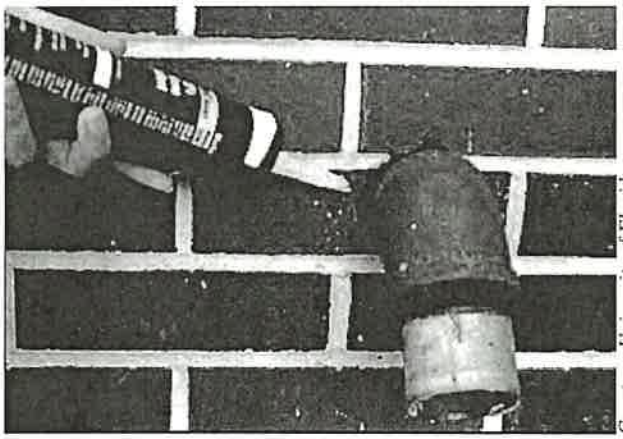


Figure 2-12. Pests may be excluded from a building through good construction techniques or by adding weatherstripping, caulking or other materials.

regularly to ensure that sanitation is maintained and to spot new problems. Tenants and persons responsible for housekeeping and landscape maintenance must be notified of conditions that promote pest buildup so they can be corrected.

Exclusion Exclusion is a type of habitat modification useful for keeping fleas, ants, cockroaches, stored-product pests, termites, rodents and other pests from entering buildings (Figure 2-12). The design and construction of a building may either promote pests or exclude them. Pest proof design and construction should be an important consideration when planning new structures or remodeling older ones.

Check building exteriors for ways that insects, rodents or other pests can enter. Obvious entrances for many types of pests are doorways and windows. These should have tight-fitting screens and doors. Properly installed weather-stripping eliminates small cracks that provide access for some pests. Check attic and foundation vents to ensure that they are tight and screened to exclude rodents, birds and bats (Figure 2-13). Look for foundation or wall cracks; gaps in siding or joints; and areas where pipes, wires or other objects pass through

Figure 2-13. Properly screened vents prevent rodents and other pests from gaining access.

walls. Fill openings with concrete or another suitable patching material, or cover openings with metal flashing. Inspect chimneys and roof-vent pipes for adequate screening.

Select pest exclusion materials according to the type of pests encountered. Refer to Table 2-3 for selection of materials for excluding pests and repairing openings. Insects can enter through extremely small openings. Mice are able to squeeze through cracks as small as 1/4 inch and many rats manage to get through a 1/2 inch opening. Rodents can chew through wood, thin metal, caulking, soft patching compounds and even some concrete mixtures. Bats, on the other hand, do not chew through walls, roofs or other surfaces, but enter structures through existing openings 1 inch or larger. Exclude bats by using thin wire mesh, sturdy cloth mesh or almost any type of well-secured patching material.

Pests can also be brought into buildings on items such as those listed in Table 2-4.

Inspection Inspect items brought into a building for pest infestation. For example, firewood may harbor carpenter ants, spiders, cockroaches, wood-boring beetles, termites or similar pests, or eggs of some pests. Furniture, rugs, corrugated boxes and other items moved from an infested building can be contaminated with cockroaches, carpet beetles or fleas. Dogs and cats bring in fleas and ticks.

Managers of grocery stores, cafeterias, restaurants or other food-handling establishments should work with pest control specialists to develop systems for examining bulk containers for cockroaches and stored product insects. Small packages of items suspected of being infested can be placed in a freezer for a few days to destroy insects. Persons responsible for purchasing can help by buying from suppliers who can deliver pest-free merchandise. Some manufacturers are now using pheromone traps in shipping containers as a way of monitoring the pest-free status of their products.

Trapping

Besides their benefits as monitoring devices, traps are used to kill or catch pests so they can be removed from an area. Many types of vertebrate and invertebrate pests can be controlled through trapping. Traps do not require potentially hazardous chemicals, and the user can easily see the success of the trapping program. However, successful trapping programs require skill, time and attention to develop as workable techniques. Even so, trapping may not always work well enough, under some conditions, to satisfactorily control target pests. Trapping techniques that are successful in one situation may not always work as well under different conditions or at other locations.

Types of traps include snap, live animal, pheromone and light trap and glue boards. Specific uses of trapping devices are described in detail elsewhere in this manual. For example, glue boards, snap and live-animal traps for rodent control are in Chapter 9.

Biological Control

Biological control is gaining more importance as a pest control method for certain insects in structures. For instance, cockroach populations have been successfully reduced in certain locations by introducing parasitic wasps. Biological

control techniques either augment other control practices or replace more disruptive or hazardous methods.

Pesticides

The application of pesticides is the most common pest control method used in and around buildings, enclosed areas and vehicles. Some pesticides provide chemical barriers to prevent insects from entering. Pesticides are also used to treat soil, wood, fabrics and other items to prevent pest damage.

Pesticides are available as baits, tracking powders, desiccants (inert dusts or sorptive powders), liquids, dusts and gases. The type of pesticide used and the kind of formulation selected is based on the life habits of the pest, its density and location. Chapter 3 discusses safe methods of pesticide use.

Pesticide Equipment and its Use

The most needed and reliable tools of all in pest management is the ability of a technician to use his/her knowledge of pest management along with well-cared-for equipment and good supplies. Pesticide application equipment used in urban pest management is, for the most part, time-tested and reliable. It is reassuring and convenient to have tools that seldom fail. Time, training, regular cleaning, calibration and repair of tools means a planned program with good supervision.

Failure to properly care for equipment can cause serious problems. Using worn or clogged spray nozzles or caked dusters results in misapplied pesticides. Accidents from breaking hoses and exposure from leaking valves can result in lost time, illness and complaints or lack of confidence from clients. Lack of attention to these activities is a sign of mismanagement of time, overscheduling, miscommunications and unclear priorities.

Item	Pests
Appliances	Mice, cockroaches
Books/papers	Cockroaches, silverfish, firebrats
Cardboard containers	Cockroaches, silverfish, firebrats; stored product moths, spiders, mice, rats (occasionally)
Carpets/rugs	Carpet beetles, fleas, cockroaches, clothes moths
Clothing	Clothes moths, lice, fleas, carpet beetles
Cut flowers	Carpet beetles, spiders
Firewood	Spiders, wood-boring beetles, termites, carpenter ants, cockroaches
Fruits/vegetables	Fruit flies, spiders, ants
Furniture	Spiders, wood-boring beetles, cockroaches, fabric pests, fleas, sometimes mice
Grains/cereals	Stored product beetles and moths, cockroaches, mice in bulk containers
Groceries/dry goods	Cockroaches, spiders, silverfish, firebrats, mice, rats (occasionally)
Lights near entrances	Spiders, carpet beetles, flying insects
Pets	Fleas, ticks
Plants	Ants, spiders, mites
Vacuum cleaner bags	Fleas, cockroaches, carpet beetles, fabric pests

Table 2-4. Ways some pests gain entry into buildings. Pests may gain entry by being carried in on items such as those listed here.

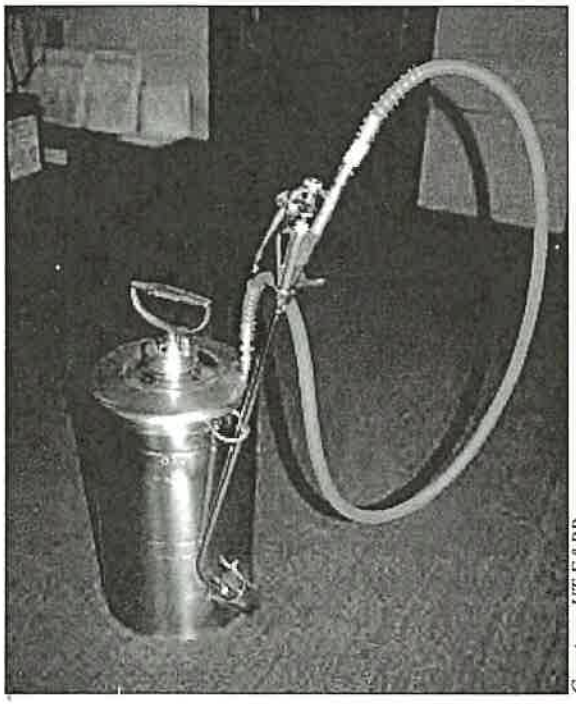


Figure 2-14. Hand-held compressed air sprayer.

Besides the flashlight, the more commonly used equipment includes:

- Bait applicators
- Bait stations
- Traps, monitoring devices, etc.
- Dusters
- Canned insecticides
- Hand-held compressed air sprayers
- Power sprayers
- Aerosol and fog generators

Hand-held Compressed Air Sprayers

The small (one or two gallon) stainless steel sprayer (Figure 2-14) is the workhorse and used to be the tool most familiar to pest control technicians. It can be used in many different ways and by many different industries. In pest management, the sprayer applies a flushing agent or a residual pesticide. Depending on the nozzle selection, the sprayer applies different spray patterns and depending on the amount of pumping, it delivers the pesticide under higher or lower pressure.

Spray Patterns The most common nozzle for the hand-held compressed air sprayer is made of brass and usually can be set in one of four spray patterns, although more than four patterns are available. The most common patterns include two-pin streams, flat-fans and cones.

Pin streams can be coarse or fine and do not produce the best crack and crevice application. Even when set for fine spray, the stream splashes back from all but the widest crack, so many nozzles have a connection for a narrow-diameter plastic extension tube. Remember to use equipment as directed (e.g., injection tool for cracks and crevices). The end of the extension tube is inserted into or at the edge of a crack

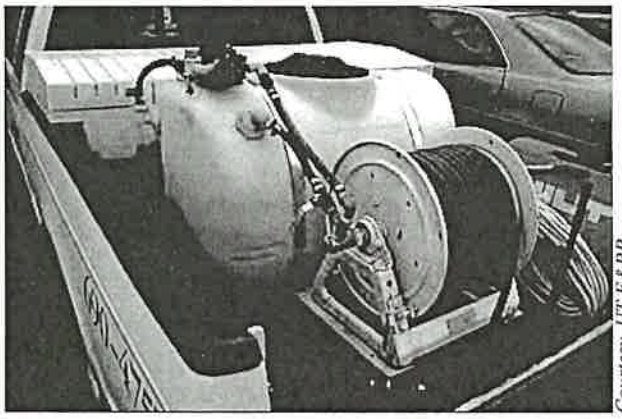


Figure 2-15. Power sprayer.

and delivers an accurate pin stream. Overall, this is the most effective spray pattern for cockroach pesticide application.

Coarse and fine flat-fan streams apply general or spot applications, as are hollow or solid cone sprays. Cone sprays deliver a circle of pesticide and are often used outside on uneven surfaces and plants.

Pressure Spray tank air pressure varies according to the amount of air the technician pumps into the tank. Pressure gauges can be attached to sprayers. Lower 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 that can drift onto nontarget surfaces. High pressure also causes splashback on surfaces or quickly traps air in crevices and keeps the pesticide from entering small spaces. As well as being uneconomical and wasteful, the practice encourages rapid application of pesticides whether they are needed or not, from distances that affect accuracy. This style of pesticide application will seldom result in effective pest control, especially where German cockroaches are a problem.

Technicians who use hand-held compressed air sprayers should periodically attend training for cleaning and sprayer maintenance. They should familiarize themselves with their own equipment and know how to repair it. It is recommended that technicians:

- rinse their sprayers daily; especially the hose, (Always empty liquid from the hose: hold the nozzle high and squeeze the trigger to drain the hose into the tank. 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,
- never use warm water to mix sprays,

(Warm water helps break down pesticides, creates droplets that easily float and increases a pesticide's odor.)

- as stressed in the core manual, always use gloves when mixing and spraying and always use safety glasses or goggles.

Power Sprayers

As their name implies, power sprayers (Figure 2-15) use electric or gasoline engines to pump liquid insecticides

from a relatively large tank, usually more than 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 urban pest control: (1) controlling termites, and (2) spraying building perimeters and lawns.

In the southern United States, power spraying outside was commonly done in conjunction with exclusion practices and inside treatment for cockroaches. In warmer climates, large cockroaches (American, oriental, smoky-brown, etc.) are active outdoors as well as indoors. Other types of outside pests (e.g. ticks, crickets, millipedes and other miscellaneous invaders) are also treated by outside spraying in addition to using exclusion practices. 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 and better penetration through short grass.

Special attention should be paid to the hose of power sprayers—both in the quality and points of wear. Wear or cuts cause hoses to burst resulting in pesticide spill and contamination to the environment and the applicator due to the higher pressure and volume. Shut-off valves should always be in good working order. Equipment to take care of spill contamination should always be carried in the service truck.

Why Calibrate Spraying Equipment?

In urban pest management, much is up to the technicians' judgment. A pest control technician should know that the proper dosage of pesticide is being applied; therefore, accurate calibration of power sprayers is important or the amount of pesticide delivered will be incorrect. Overdosage will contaminate the spray area, result in runoff and cost money. Less than recommended dosage may fail to control the pest. Technicians need to regularly look at the output of their equipment. Flow meters are very helpful to let them know the output of the sprayer over time.

- It is estimated that 60 percent of sprayers have a calibration error of 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 different applicators vary, depending upon 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. Refer to company policy and core manual for calibration instructions.

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 urban pest management include canned aerosol foggers (volumetric sprays, total release fogs) and pressurized liquid sprays.

Canned Aerosol Pesticides Canned aerosol pesticides (Figure 2-16) consist of a pressurized fluid that produces an aerosol or fog droplets that float 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. Pests that have left hiding places, and any other flying insects, contact the droplets and are 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 remains airborne. Compressed 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. In a closed crevice, the expanding gas propels the insecticide in all directions, forcing it on all surfaces in the crevice rather than shooting it across in a straight line like a compressed air sprayer. Using canned pressurized liquid sprays requires a firm understanding of the target pests' habits so that pest harborage can be effectively treated.

Aerosol and Fog Generators

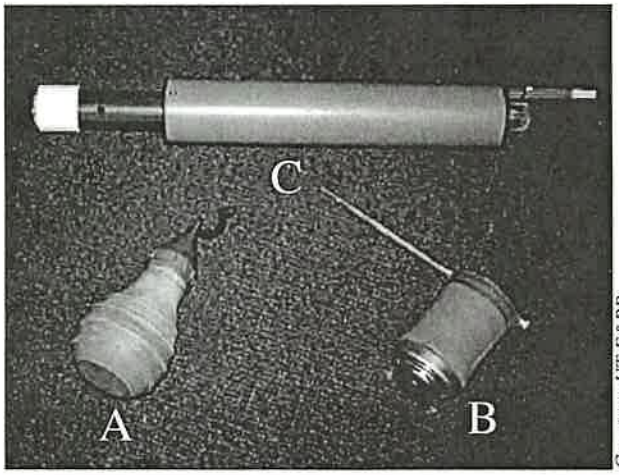
Power aerosol and fog generators (Figure 2-17) break liquid pesticides into aerosol droplets. Reducing the liquid into droplets is done either mechanically (cold foggers) or by using heat (thermal foggers). Caution should always be taken

Courtesy, UT E&PP

Figure 2-16. Canned aerosol pesticides consist of a pressurized fluid that produces an aerosol or fog droplet.

Courtesy, UT E&PP

Figure 2-17. Fogger.



Courtesy, UT E&PP

Figure 2-18. Three types of hand dusters used by pest management professionals: bulb (A), bellows (B) and plunger dusters (C).

Courtesy, UT E&PP

Figure 2-19. Power duster.

to protect the applicator's respiratory system with a canister-type respirator 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 relatively large areas. 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.

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

For general application A few precautions when using fogging or aerosol generating equipment include:

1. Applicators should wear respirators.
2. Occupants must leave until the area has been adequately ventilated.
3. Pets must be removed; house plants and aquariums must be covered, and aerating pumps turned off.
4. Exposed foods and food-preparation surfaces must be protected. After treatment, all food-preparation surfaces and any exposed utensils must be washed.
5. Pilot lights and any other open flame must be extinguished. This is particularly critical when the oil-based thermal fog is used. Any spark can cause an explosion in a thermal-fog atmosphere.
6. Thermal-fog generators can burn surfaces that they contact, including the operator.
7. 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.)
8. 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.)
9. After an appropriate interval, and before people or pets reoccupy the area, treated rooms should be thoroughly aired.

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

Courtesy, UT E&PP

Figure 2-20. Multiple-catch trap for mice.

Courtesy, UT E&PP

Figure 2-21. Some baits used for insect control.

treatments begin to be used at increasingly closer intervals, it means that the pest population is not being suppressed and may be increasing.

Dusters

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

Three types of hand dusters are commonly used by pest management technicians: bulb, bellows and plunger dusters (Figure 2-18). Dusts are also driven by gas in some formulations of canned insecticides, but with this method, dusts are applied like 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 is applied, the more dust is 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 for refilling. Dust application is much like 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 urban pest management is smaller, made of high-impact plastic and has several nozzle styles.

Power Dusters Most power dusters (Figure 2-19) 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 much like 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.

Power dusters are often used in spaces where the dust can lie undisturbed, providing a residual pesticide coating. They are also applied in sewers as contact pesticides and in trash chutes of high-rise buildings. The dust is introduced at the lowest level at a trash compactor and rises up through the chute where it is vented at the top. The chute must be closed at each floor. Dusts can also 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 nontarget spaces. If using a combustible dust, remember to turn off pilot lights and flame- or spark-producing equipment. 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 washed and dried often.

Traps, Bait Boxes, Monitoring Devices and Pheromone Dispensers. Traps (Figure 2-20) have been used for pest control for centuries. Rodent-control traps range from snap traps to boxes with trap doors, spring-loaded multiple-catch and small animal traps. Rodent bait boxes, or bait stations, are containers that hold poisonous baits or glue boards. Under certain conditions, they must be tamper proof for safety. Bird traps allow the birds to enter, but they 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. Electric fly traps are made with an attracting light that lures flies to electrocution grids or glue boards. 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 and Applicators There are many kinds of bait and bait stations (Figure 2-21). These devices confine toxic substances to units that are removable rather than leaving them exposed. Cockroach bait stations offer pesticides

Figure 2-22. Bait applicators allow bait placement into cracks and crevices.

as attractive bait. The bait stations themselves offer natural harborage. 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. Gels and other baits may be applied with a bait applicator or syringe (Figure 2-22). These applications may be calibrated to deliver a given quantity of bait.

In urban pest management, equipment helps suppress pest populations; however, it is effective only when used by competent pesticide applicators. Pest control equipment used by an untrained applicator who has little practical knowledge will be ineffective. Ill-cared-for equipment is ineffective and dangerous.

To use pesticides efficiently and economically (without under application [lack of control] or over application [unsafe]), applicators must understand their equipment capabilities and be able to depend on correct calibration. They must also be aware of the many types of equipment available. Urban pest control equipment is not only sprayers and dusters, but includes other devices such as traps, bait stations, lights, excluders, etc.

Review Questions

1. New sprayers are well calibrated until they have been used one season.
   A. true
   B. false

2. IPM stands for _____.
   A. insect pest management
   B. integrated pest management
   C. intelligent pest management
   D. interactive pest management

3. Fogging fills a room volume, including cracks, crevices and cabinets.
   A. true
   B. false

4. High pressure must be maintained in hand-held sprayers to be effective.
   A. true
   B. false

5. If a sprayer malfunctions, _____.
   A. repair it immediately
   B. increase pressure by pumping
   C. release pressure and remove it to a repair area
   D. use very soft thin wire to clear nozzle after releasing pressure

6. Equipment safety is best maintained by_____ _____.
   A. daily rinsing
   B. daily hose inspection
   C. scheduled cleaning
   D. all of these

7. To apply pesticides in a school, applicators must: _____.
   A. buy their product from a commercial applicator.
   B. use pesticidal bait given to them by the official school custodian.
   C. work under the supervision of a person licensed to apply pesticides.
   D. be certified to apply pesticides, but not under the supervision of a licensed operator.

8. Which of the following pesticide application reduce exposure to building occupants?
   A. fogging
   B. bait stations
   C. spraying baseboards
   D. timed-release aerosol

9. Which of the following is not a detection or monitoring device?
   A. pheromone trap
   B. light trap
   C. pherbionone trap
   D. glue board

10. Habitat modification includes: _____.
   A. removal of access to food, water and harborage sites
   B. using baits
   C. applying sprays in cracks and crevices
   D. all of the above.

11. Pesticides do not play a role in an IPM program.
   A. true
   B. false

12. _____ lights are better for use outdoors because they emit a spectrum of light that is less attractive to insects.
   A. Sodium vapor
   B. Mercury vapor
   C. Incandescent
   D. White

Answers: 1. B, 2. B, 3. B, 4. B, 5. C, 6. D, 7. C, 8. B, 9. C, 10. A, 11. B, 12. A

Chapter 3 Using Pesticides Safely

When you apply any pesticide, you assume the legal responsibility for using it strictly in accordance with label instructions. You must always protect people who live or work in the treated area so they are not exposed to harmful residues. Avoid using pesticides or application methods that might injure nontarget animals or plants, or damage property. Pesticide use should not endanger the environment or cause contamination of groundwater, soils, air or human and animal foods. In addition, you must use pesticides in ways that avoid excessive exposure to any part of your own body. This chapter gives a brief introduction to pesticide types, formulations, hazards and safety precautions for pesticides used in pest and rodent control. Precautions that must be observed when handling pesticide containers, guidelines for mixing pesticides, some steps to properly apply pesticides, ways to safely store these materials and information on pesticide disposal are summarized in this chapter.

The most common pesticides used in and around structures are insecticides and rodenticides. Occasionally, fungicides or herbicides are used to control pests near buildings. Wood preservatives are a special class of pesticide used to protect structural and decorative wood, utility poles and marine pilings.

Handling Pesticide

Undiluted pesticides in their original containers must be handled carefully. Wear rubber gloves and protective clothing, such as a waterproof apron, when handling pesticides. Do not drop or throw containers or packages because this may cause damage and leaks. Check for contamination or leaks on all packages being handled, and do not let damaged packages or spilled pesticide come in contact with your skin or clothing. If a container is damaged and leaking, the pesticide should be transferred to another container and must be properly identified. When working around a leak, you may need to wear respiratory and eye protection—check the pesticide label for all precautions and required safety equipment. Never walk through a spilled pesticide.

Never leave pesticide containers unattended or stored in unlocked areas. Always keep pesticides away from food and water and away from sources of heat and fire. Never allow paper containers to get wet.

Do not eat, drink or smoke while handling pesticides and pesticide containers. Wash thoroughly when you finish handling pesticide containers and before eating, drinking, smoking or using the bathroom.

Applying Pesticides

To apply pesticides correctly, you must make sure that the correct amount of active ingredient is applied to the area to be treated and that the pesticide is confined just to that area.

Here are some important things that you must do to properly apply pesticides:

- Calibrate the application equipment accurately.
- Use the correct amount of active ingredient. Check the pesticide label for rates of application.
- Measure the area to be treated so the correct quantity of pesticide mixture can be prepared.
- Check the application site for hazards that might affect the safety of the application. Hazards include electrical outlets and exposed wiring, sources of ignition such as flames or sparks, confined spaces and improper ventilation. Hazards also include irregular surfaces over which the applicator or equipment must travel.
- Make sure that the weather conditions are suitable for pesticide application. This includes temperature, humidity and, if making outdoor applications, wind, fog and rain.
- For liquid sprays, control the droplet size and spray pressure to prevent drift and to keep the spray on target.
- Set up an application pattern that prevents you from having to walk or drive through treated areas.
- Do not apply pesticides in or near air conditioning or heating vents or ducts.
- Keep people and animals away from the area during application and until the treated area is safe to re-enter.

Storing Pesticides

Store pesticides in their original, tightly closed containers. Whenever possible, wipe or wash pesticide residue off the outside of containers before they are put into storage. Protect pesticides from extremes in temperature and from becoming wet. A pesticide storage area should be a separate building, away from people, living areas, food, animal feed and animals. The area must be well ventilated, well-lighted, dry and secure, with lockable doors and windows. Post signs near all primary entrances to warn others that the building contains pesticides.

Some pesticides do not store well for long periods of time. Extended storage, especially after temperature extremes, may cause chemical changes resulting in some products losing their effectiveness or others becoming more toxic. Moisture and air picked up during storage may alter the composition of some pesticides, especially those stored in unsealed containers. Solvents and petroleum-based chemicals can degrade some types of containers after a period of time. Store baits separately from other insecticides so they do not pick up odors and make the bait unpalatable.

Most pesticide chemicals should not be stored for longer than two years. Before pesticides exceed their shelf-life, use them in an appropriate application or transport them to an approved disposal site.

Pesticide Disposal

Here are some important things to remember when disposing of pesticides:

- Leftover pesticide mixtures are considered hazardous wastes unless they can legally be used to control pests in another site.
- Whenever possible, mix only the amount required for each job.
- Excess pesticide must never be indiscriminately dumped; such dumping is a potential source of environmental and groundwater contamination and is illegal. Persons convicted of dumping are subject to large fines and jail terms.
- Rinse water from cleaning of equipment is also a hazardous waste and must be treated accordingly. Either spray on a labeled site or dispose in an approved manner.
- Hazardous materials such as excess pesticides, leftover pesticide residues or rinsate must be transported to an approved Household Hazardous Waste Collection Center or a state or county sponsored pesticide round-up day or contracted for disposal with a registered hazardous waste transporter.
- Pesticide containers must be triple rinsed before they can be disposed of in a Class 1 disposal site.
- For more information, check with the Tennessee Department of Environment Conservation, Division of Solid/Hazardous Waste Management for methods of disposing of hazardous pesticide wastes and empty pesticide containers.

Pesticide Types

The most common pesticides used in and around structures are insecticides and rodenticides. Occasionally, fungicides or herbicides are used to control pests near buildings. Wood preservatives are a special class of pesticide used to protect structural and decorative wood, utility poles and marine pilings.

Pesticides used for general household use are available in several types of formulations. Insecticides and rodenticides can be applied as baits (treated grains, meals or other substances), liquids, granules, gases or dusts. Some insecticidal dusts are used as tracking powders or desiccants. Fungicides and most herbicides are generally applied as liquid sprays, although some herbicides are available in a granular formulation.

Pesticides used for general household pest control are available in several types of formulations.

Wettable Powder (W or WP) The pesticide is not soluble in water. It is combined with a finely ground material such as clay and combined with other ingredients to improve mixing. Most wettable powders contain between 25 and 80 percent active ingredient. When mixed with water, they form a suspension that must be kept agitated during application. Wettable powders may be abrasive to nozzles and pumps, but they are one of the safest formulations for use on plants for insect or disease control. Wettable powders usually leave a visible residue.

Dry Flowables or Water-Dispersible Granules (DF or WDG) This formulation is similar to a wettable powder but is in the form of granules that must be mixed with water before use. These pesticides require agitation during use. Usually there is a higher percentage of active ingredient in this formulation than in wettable powders. These are measured by volume rather than weight. Like wettable powders, dry flowables are abrasive to application equipment.

Soluble Powders (S or SP) Soluble powders dissolve with water in the spray tank after mixing to form a true solution. These do not require agitation once they have been thoroughly mixed, and they are not abrasive to nozzles or pumps. (Only a few pesticide active ingredients are soluble in water.)

Emulsifiable Concentrates (E or EC) Emulsifiable concentrates are pesticides that are soluble in an organic solvent but not in water. Pesticides highly soluble in oil pass through skin faster than pesticides highly soluble in water. Emulsifiable concentrates are petroleum-soluble pesticides formulated with emulsifying agents (soaplike materials) and other enhancers. The emulsifiers enable the dissolved pesticide to form a suspension. When the undiluted formulation is combined with water, a milky emulsion is formed that must be kept agitated during application to keep the emulsion uniform. ECs are not abrasive to application equipment, but the solvent may contribute to the deterioration of rubber and plastic seals and hoses of the application equipment. The solvent may also injure plant foliage and may cause damage to certain types of surfaces. Emulsifiable concentrates usually contain between 2 and 8 pounds of active ingredients per gallon.

Flowables (F) Flowables consist of finely ground pesticide combined with a liquid solvent and emulsifiers. When mixed with water, they form a suspension similar to a wettable powder. Flowable formulations must be agitated during application. These may be abrasive to application equipment components. They leave visible residues on treated surfaces.

Water-Soluble Concentrates or Solutions (S) Water-soluble concentrates or solutions dissolve in water to form a true solution. Once dissolved, they do not require agitation. They are nonabrasive. Only a few pesticide active ingredients are soluble in water.

Liquids

Pesticide liquids are mixtures of powdered or liquid active ingredients combined with liquid carriers such as water or oil. Pesticides may dissolve in the carrier to form a solution or may remain suspended in the liquid to form an emulsion or suspension. Suspensions and emulsions require constant agitation to maintain a uniform spray mixture.

Liquid pesticides are applied as spot treatments, crack-and-crevice treatments, fogs or mists in confined areas, or general sprays to large areas. The common ways to apply liquid sprays are with aerosol dispensers, hand-held compressed air sprayers, backpack sprayers or larger, motorized spray units (Figure 2-15). When liquid sprays are applied, a residue of pesticide-active ingredient remains on the treated surfaces and helps to control pests over a period of time. The length of time depends on the type of pesticide used, the type of formulation, the concentration of active ingredient applied, the type of surface treated and environmental influences such as temperature, humidity or sunlight. Undiluted pesticides contain concentrated amounts of active ingredients that may cause serious injury if inhaled, splashed or blown into the eyes, or spilled on the skin or clothing. Some concentrated pesticides may be flammable.

Applying liquid sprays in certain areas may be extremely hazardous. For example, electric outlets, motors or exposed wiring pose a potential threat of electrical shock to persons applying water-based pesticide sprays. Pilot lights and gas flames from heaters and appliances may ignite flammable petroleum-based pesticides. Sparks from electric motors and switches and glowing heating elements may also ignite flammable materials. Pesticide vapors or fumes in confined areas may injure people if ventilation is inadequate.

Gases

Gases that kill pests are fumigants. Fumigants control certain stored-product insects, drywood termites and wood-destroying beetles, soil-infesting nematodes, soil pathogens and some rodents. The process of applying fumigants, or fumigation, is much different from other forms of pesticide application and requires special training, licensing and equipment.

Dusts

Dust formulations are finely ground dry powders that contain toxic materials. They contain a low percentage of active ingredient (1 to 10 percent) mixed with a finely ground inert substance such as talc, clay, nut hulls or volcanic ash. These are sometimes used to control rodents and certain insects. Most dusts are blown into inaccessible places where pests hide. Dusts do not penetrate surfaces and usually break down slowly. Therefore, the active ingredient in dust formulations remains on the treated surface and is active against pests for a long period of time if the treated area stays dry. Because they do not penetrate, dusts are more effective than liquids on absorptive surfaces such as concrete.

Dusts may be applied in cracks and crevices, under cabinets or appliances and in other areas inaccessible to children and pets. This formulation leaves visible residues on treated surfaces, which often limits its use to areas such as warehouses, attics, crawl spaces and wall voids.

Dusts usually provide better coverage than sprays in inaccessible or hard-to-reach places. In wall voids, they can be dispersed with compressed air to reach all surfaces. During manufacture, dusts are sometimes given an electrical charge or they are combined with an electrically charged powder to make them cling to surfaces better. Bulb applicators, shaker cans, aerosol cans and compressed air dusters are used to apply these formulations.

When using dusts, prevent their drift into the airspace of rooms or work areas. Apply dusts only according to the instructions on the pesticide label. **Always wear approved respiratory protection to avoid inhaling dust particles.**

Toxic Tracking Powder Toxic tracking powder is a dust formulation that may be useful where rodents won't accept bait or there is an abundance of natural food. Target rodents pick up the toxic dust on their body surfaces as they walk through it and later ingest some during grooming. The toxic component of some tracking powders can also be absorbed through the animal's skin.

Apply toxic tracking powder to runways alongside walls, inside wall voids, and in attics and crawlways. Blow the powder into inaccessible areas where rodents are known to travel. Avoid the use of power blowers in exposed areas to prevent dispersing the powder beyond the treatment site. Once control has been accomplished, remove remaining powder from exposed parts of the treatment site. To remove powder, use a vacuum equipped with an HEPA filter approved for pesticides. Once the area has been cleaned, dispose of the filter and vacuum bag in an approved hazardous-waste disposal site.

Follow label directions for using a toxic tracking powder and carefully select locations where the powder is to be used. Do not put powder where it can be dispersed by air movement or tracked by pests onto food, eating utensils or food-preparation surfaces. Never use toxic tracking powder on shelves, cupboards or ceiling beams overhead in food preparation or eating areas. Because of the hazards, do not use toxic tracking powder in food-processing plants or food-storage warehouses; never apply it in or around homes except inside wall voids or other inaccessible areas. In locations where people or animals may accidentally contact the powder, confine its use to bait stations; the combination of toxic tracking powder and toxic bait can sometimes be very effective. Do not use toxic tracking powders unless you can ensure that nontargets, including humans, will not be exposed.

Toxic tracking powder loses some of its effectiveness in damp areas because moisture causes the powder to cake

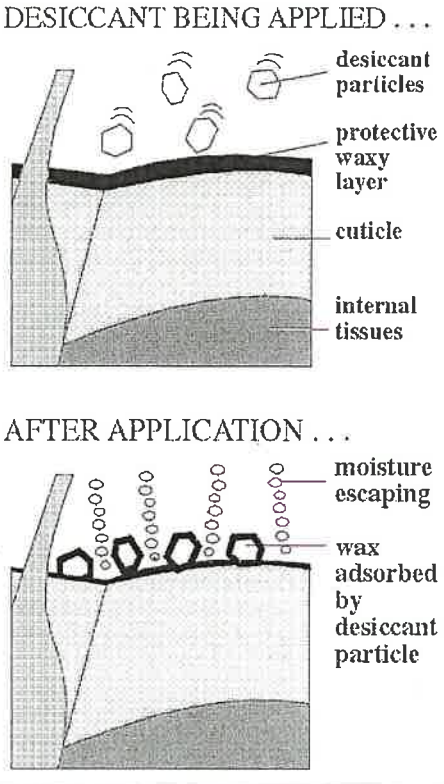
and not stick to the animal's body; it may also speed the breakdown of the toxic material. Toxic tracking powder formulations are fast-acting poisons; therefore, rodents die quickly. Rodents dying in inaccessible wall voids or other out-of-the-way areas could create odors or attract flies.

Desiccants

Desiccants are dusts or sorptive powders used to control some insect pests found in buildings. The powder abrades or absorbs the waxy coating that protects insects from losing water (Figure 3-1). Desiccants often last longer than other forms of insecticides; however, insects must move through the dust and pick up some on their bodies for it to be effective. To apply, blow desiccants into wall voids, attics and crawl spaces, and dust them into other areas where insects hide. Some desiccants are highly repellent, which helps exclude insects from treated areas. Avoid breathing dusts during application by wearing respiratory protection.

Granules

Granular formulations are sometimes used to control ants, sowbugs, earwigs, snails and slugs, and occasionally other soil-inhabiting organisms. Usually, granules are combined with a food substance or attractant to encourage target pests to feed on them. Granular formulations are dry, ready-to-use materials usually containing from 5 to 20 percent active ingredient. Do not apply granules in areas where children or pets may find them.



Courtesy, University of Florida

Figure 3-1. Dessicants destroy insects and mites by removing or disrupting the protective outer body covering. This causes the organism to lose body fluids.

Poisoned Bait

Poisoned bait may be used to control specific types of insects, as well as snails, slugs and rodents. Pigeons, starlings and English or house sparrows may be controlled with a poisoned bait if the certified technician is working under the direction of a person licensed in bird control (BDC). All other birds are protected; a special permit is required from Tennessee Wildlife Resource Agency (TWRA) to manipulate these populations.

Most baits are a combination of pesticide and food material. Most bait formulations contain less than 5 percent active ingredient. They may be in the form of powders, grains, granules, kibbles or blocks. Baits are usually placed in a bait station or secured in protected places (Figure 3-2, 3-3). Baits used to control snails or slugs, earwigs or oriental cockroaches are usually broadcast over the soil around the outside of a structure.

Choose bait types and bait-station styles on the basis of (1) type of pest, (2) history of bait use, and (3) conditions of the baiting location. For example, when baiting for ants, select a bait that foraging workers will carry back to the nest to feed to the colony's reproductives and brood; the toxic substance must be slow-acting so that foraging workers are not killed before they reach the nest. Bait used to control flies, on the other hand, must be fast-acting to stop continued annoyance and prevent further egg laying.

Certain rodent baits contain an anticoagulant, which interferes with the animal's normal blood clotting process. It is important for rodents to feed on some anticoagulant baits over a period of several days so they will consume enough toxic material to be effective. If there is an interruption of feeding for longer than 48 hours, the animal will recover and accumulated toxic effects will be lost. To prevent this from happening, check and refill bait stations regularly. Other anticoagulant baits are effective after a single feeding.

Courtesy, UT E&PP

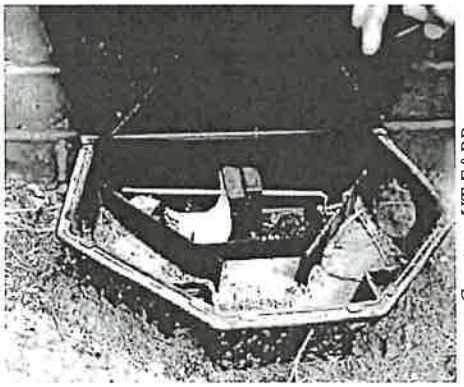
Figure 3-2. Poisoned baits are usually placed in bait stations to prevent children or nontarget animals from being exposed to the toxic material.

Selecting a bait for rodent or bird control also depends on where it is to be placed. Toxic powders, poisoned grains and granular formulations used indoors usually need to be confined to bait stations. Bait blocks can be used without a bait station, but place them where they can be secured and are out of the reach of children, pets and nontarget animals. In damp areas, use rodent bait in the form of paraffin blocks that can withstand moisture; the wax keeps the bait fresh and helps prevent mold. Do not apply powdered or granular baits to shelves or floors in areas where they can be hazardous to children or pets, or cause contamination of food and other items.

Insects may infest poisoned rodent bait if it is left in a bait station for a long time, so replace bait frequently. Remove uneaten bait and thoroughly clean bait stations. Dispose of old or unused bait in an approved hazardous waste disposal area. Contact the local Extension office for information on toxic material disposal.

Rodent Bait For controlling rodents, place bait near nests and along runways. Rats usually do not go out of their way to find it and mice confine their activities to small areas most of the time. To improve the chances of its being discovered, place bait in several areas rather than in just one location. Each of the bait locations for mice, for example, should be no more than 10 feet from another source of bait. Whenever possible, put bait under cover of some object so the rodents feel secure while feeding. Secure bait for roof rats in rafters, trees or other elevated areas. For Norway rats, place bait along the bases of walls and near ground burrows. It is also possible to place bait in burrows and put a rock or other heavy object over the burrow opening so children and nontarget animals cannot reach it.

Insect Bait Put insect bait in areas of greatest activity or in those that cannot be sprayed or dusted. For ants, locate the bait along trails, near nest entrances, around the foundation of the building and under sinks and other out-of-the-way locations inside the building. Apply cockroach bait under appliances, under sinks, behind furniture and in hidden areas where these insects have been observed or are suspected to occur; place bait at wall intersections, as cockroaches tend to travel along edges. For cockroach species that occur outdoors, place baits around or in woodpiles and in water-meter boxes and other protected locations where these insects are usually found.



Courtesy, UT E&PP

Figure 3-3. Rodent bait should be placed in the baffle portion of the bait box so the bait cannot be dislodged.

Bait Stations Be sure bait stations are suitably designed for the kind of bait used and the baited pest. For rodents, use stations that comply with the rodenticide label. These should be large enough to accommodate several rats or mice at a time. Provide at least two 1 inch openings into the feeding station for mice and two 2 1/2 inch openings for rats. Multiple small openings are an important feature for an insect bait station.

Use only tamper-proof bait stations to prevent children, pets or nontarget animals from gaining access to the bait.

A tamper-proof bait box must meet the following criteria to be acceptable for use:

1. Resistant to weather. Placement of the bait station influences weather resistance. If the bait box is placed outside, it needs to be more resistant than if placed indoors or under a shelter.
2. Strong enough to prohibit entry by large, nontarget species. Placement may be a factor if the bait box is inaccessible to nontarget species because it is located inside a building or shelter.
3. Equipped with a locking lid.
4. Equipped with entrances that readily allow target animals access to baits while, at the same time, denying access to larger nontarget species. Access to larger species may be restricted by using bait boxes with baffles, mazes or small entrances.
5. Capable of being anchored securely so that the bait box cannot be moved or its contents displaced.
6. Equipped with an internal structure for confining the bait. In most boxes, this consists of an arrangement of baffles.
7. Made in such a way so as not to be an "attractive nuisance."
8. Capable of bearing precautionary statements in a prominent location. The bait box must meet service container labeling requirements. Be sure the word "Poison" is clearly printed on each bait station. Bait stations are considered to be service containers, so they must be labeled with the following information: (1) the name and address of person or firm responsible for the bait station; (2) the identity of the poison being used; and (3) the signal word from the pesticide label.

Resistance and Bait Shyness If baiting has been used before, but control was not successful, the target pest may be developing pesticide resistance or bait shyness.

Pesticide resistance is an acquired condition that gives the target pest population the ability to tolerate or detoxify the toxic substance (Figure 3-4). When resistance is suspected (if pests are eating the bait but the population is not declining), switch to another control method, such as trapping. Otherwise, use a toxicant that has a different mode of action and augment the baiting program with other control methods. Try discontinuing the use of bait for several months to reduce the chances of further resistance.

Bait shyness develops if an individual animal dislikes the bait or has had a bad experience with it. Bait may be

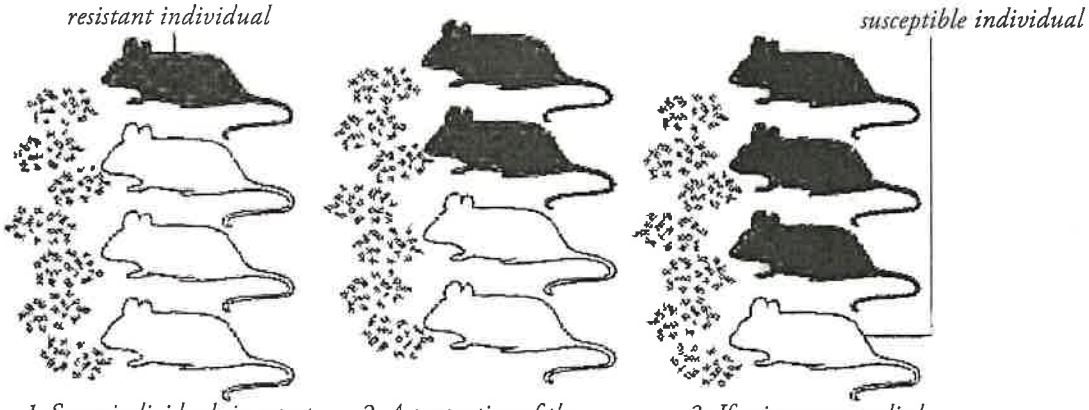


Figure 3-4. This drawing illustrates how pesticide resistance can build up in a pest population. Resistance to pesticides involves a change in the genetic characteristics of pest populations which are inherited from one generation to the next. Increase or frequent use of a pesticide often hastens resistance.

unattractive because it is old, moldy or contaminated. If pest rodents are not feeding on the bait, check to be sure it is fresh and uncontaminated; use another type of attractant and select a toxicant with a different mode of action to see if this improves acceptance. Be sure bait is located in areas where target pests have access to it. Sometimes prebaiting—setting out the same type of bait minus the toxicant—is helpful in overcoming bait shyness. Once the nontoxic bait is taken regularly, switch to the toxic bait.

Human Pesticide Injury

Poisonous chemicals such as pesticides injure or kill people by interfering with the normal functioning of internal organs and systems. The nature and extent of injury depends on the toxicity of the chemical as well as the dose (amount of material) that enters the body's tissues. A person's health and size may also influence the severity of injury.

The ingredients of some pesticides are very potent and are capable of causing poisoning at doses as small as a few drops or a few ounces. Other less-potent pesticides might require that as much as several pounds be consumed before signs of illness appear. Regardless of the specific potential hazard, anyone working with pesticides should avoid exposure by using suitable protective clothing and application techniques. Anyone living or working in pesticide-treated areas must be protected from exposure levels that will cause injury.

Poisoning Symptoms

Symptoms are abnormal conditions, feelings or signs that indicate the presence of an injury, disease or disorder. When a person is exposed to a large enough dose of pesticide to cause injury or poisoning, some type of symptoms will usually appear (Table 3-1). These symptoms may show up immediately or after several days; sometimes they may not appear until after several months or years. It may be difficult to associate the illness or injury with its cause if there has been a lapse of time between exposure and observable effect.

The effect of an exposure can be localized, such as eye or skin irritation, or generalized, when the pesticide is absorbed into the blood and distributed to other parts of the body. A pesticide can affect several different internal systems at the same time. If the person experiences an injury but recovers quickly, or gets worse and dies within a short time, it is known as an acute illness or injury. If the effects last for a long time, and perhaps are irreversible, it is known as a chronic illness.

Avoiding Pesticide Exposure

There are many things you can do to avoid pesticide exposure when working around pesticides or applying them. Follow these guidelines:

- Wear clean protective clothing whenever you work around pesticides or work on application equipment.
- Wash thoroughly before eating or drinking, smoking or using the bathroom.
- Change clothes and bathe after handling or applying pesticides.
- Check the pesticide label for protective clothing requirements.
- Practice safe mixing and application methods.
- Never walk or drive through freshly treated areas.
- Clean up leaks and spills as soon as they occur.
- If any pesticide spills on you, remove contaminated clothing immediately and wash thoroughly with plenty of soap and water.
- Whenever possible, select the least hazardous pesticides.
- Reduce pesticide use by combining chemical control methods with non-chemical control methods.
- Apply pesticides only as spot treatments and time the applications to coincide with the most susceptible stage of the target pest.

Examples of chronic illnesses usually associated with high or prolonged levels of exposure to certain pesticides include, among others, infertility, birth defects and cancer. Pesticides that are found to cause such disorders or are suspected of causing these problems may lose their federal registration and can then no longer be used in the United States.

Some pesticide poisoning symptoms are similar to symptoms produced by many other chemicals. Symptoms may vary between chemical classes of pesticides and may also be different among pesticides within the same chemical class. The presence and severity of symptoms usually are proportional to the amount of pesticide (dosage) entering the tissues of the exposed person. Symptoms may include a skin rash, headache or irritation of the eyes, nose, or throat; these symptoms may go away within a short period of time and sometimes are difficult to distinguish from symptoms of an allergy, cold or the flu. Other symptoms, which might be caused by higher levels of pesticide exposure, include any of the following: blurred vision, dizziness, heavy sweating, weakness, nausea, stomach pain, vomiting, diarrhea, extreme thirst and blistered skin. Poisoning can also result in apprehension, restlessness, anxiety, unusual behavior, shaking, convulsions or unconsciousness. Although these symptoms can indicate pesticide poisoning, they also may be signs of another physical disorder or disease. Whenever the possibility of poisoning exists, consult a physician. Be sure to give the physician a copy of the pesticide label or the name of the pesticide, the manufacturer and the EPA registration number. Diagnosis of a pesticide-caused injury usually requires careful medical examination, laboratory tests, observation and familiarity with a person's medical history.

Individuals commonly vary in their sensitivity to pesticides. Some people show no reaction to a dose that causes severe illness in others. A person's age and body size may influence his or her response to a given dose; thus, infants and young children are normally affected by smaller doses than those affecting adults. Also, adult women may be affected by smaller doses of some pesticides than adult men. The unborn child carried by a pregnant woman may be highly sensitive to exposure to some pesticides.

Pesticides that are applied in strict accordance with their label instructions with adherence to application rates, reentry intervals, protective equipment requirements, aeration periods and other listed procedures generally do not leave unsafe levels of pesticide residues. Accidents during application may result in a higher, and sometimes unsafe, exposure. An improper application caused by failure to follow label instructions may also result in injury and legal liabilities.

Human Protection

Always apply pesticides in strict accordance with label instructions. Furthermore, never use a pesticide in a building or other area unless people living or working there can be protected from exposure. This often requires that they leave the area before an application begins and that they remain away for a period of time after the application. Provide occupants with information about the pesticide application and be sure they understand the safety precautions taken. The type of information they may need includes: (1) the name of the material being used; (2) poisoning symptoms and what to do if they experience such problems, where to get help and how to get more information; (3) what areas of the building are being treated; (4) what to expect, such as an odor or residue; and (5) the possibility of finding dead insects or rodents and what to do if this happens. Explain ways to reduce personal exposure, such as removing or covering food and utensils before pesticide applications, protecting linens and bedding and similar items, opening windows and doors to increase ventilation and vacuuming carpets and cleaning floors after an application and keeping children and pets away from treated areas.

Pesticides may be needed to control pests in places where food is stored, prepared or eaten. If so, special precautions must be taken. For instance, never treat food-preparation surfaces with dusts or liquid sprays and do not allow residues to drift onto food or utensils. If fogs are used, all food preparation surfaces must be thoroughly cleaned after application.

Never make an application near air ducts or ventilation systems unless the system can be shut down for a period of time. Do not apply pesticides inside heating or cooling ducts.

Infants, Children, the Elderly and People with Medical Conditions

Sometimes the use of pesticides in buildings must be restricted or avoided to protect people living there. Rely on non-chemical control methods as much as possible and use a pesticide only where absolutely necessary. When pesticides are needed, choose the least-toxic formulation available, such as a bait or a low-volatility liquid spray. Follow label instructions and precautions carefully. Be extremely careful when using pesticides in areas occupied by infants, children, the elderly or someone who is sick. These areas include hospitals, nursing homes, schools and certain households.

Infants are more vulnerable to pesticide exposure than larger children or adults. This is because of their small size and undeveloped immune system responsible for detoxifying hazardous chemicals. Do not apply a pesticide to anything used for infant care, and avoid spraying or dusting carpets, clothing, blankets, towels or any fabrics that infants may contact. When a pesticide is needed in areas where an infant may spend part of the day, use a formulation that will break down completely before the infant returns.

Children under the age of six are active and curious. It is difficult to keep them away from places where a pesticide has been used for household pest control. Young children explore a lot and put many objects (including their hands) into their mouths. They also crawl on floors and climb on other surfaces. Therefore, never apply a pesticide to play equipment, toys or any surfaces youngsters normally touch. On carpets, use pesticides that break down rapidly. In all cases, use pesticides with low toxicity and low volatility. If you use bait stations or traps, secure them well out of reach and sight.

Elderly people may be susceptible to respiratory illnesses and other disorders that may give them a low tolerance to many airborne dusts and chemicals, including specific pesticides. In some instances, their bodies may not be able

POSSIBLE SYMPTOMS RELATED TO SKIN CONTACT WITH PESTICIDE DUST, LIQUID, OR VAPORS

Staining of the skin
Reddening of skin in area of contact
Mild burning or itching sensation
Painful burning sensation
Blistering of the skin
Cracking and damage to nails
Involvement of internal systems resulting in blurred vision, dizziness, vomiting, or diarrhea
Possible muscle weakness, poor coordination, muscle cramps
Potential chronic problems (see below)

POSSIBLE SYMPTOMS RELATED TO EYE CONTACT WITH PESTICIDE DUST, LIQUID, OR VAPORS

Discomfort, including watering and slight burning
Severe, painful burning (permanent eye damage may occur)
Involvement of internal systems resulting in blurred vision, dizziness, vomiting, or diarrhea
Possible muscle weakness, poor coordination, muscle cramps
Potential chronic problems (see below)

POSSIBLE SYMPTOMS RELATED TO INHALING OR SWALLOWING PESTICIDE DUST, LIQUID, OR VAPORS

Sneezing
Irritation of nose and throat
Nasal stuffiness
Swelling of mouth or throat
Coughing
Breathing difficulties
Shortness of breath
Chest pains
Involvement of internal systems resulting in blurred vision, dizziness, vomiting, or diarrhea
Possible muscle weakness, poor coordination, muscle cramps
Potential chronic problems (see below)

CHRONIC PROBLEMS

Exposure to some types of pesticides may result in chronic problems such as cancer, infertility, birth defects, or genetic disorders to the exposed person or their offspring. Symptoms of these disorders may not appear until years after exposure. Repeated exposure to low doses of certain pesticides over long periods of time may increase the potential for chronic health problems; single incidents of high-level exposure to certain pesticides may also increase the possibility of chronic health problems.

Table 3-1. Common Pesticide Poisoning Symptoms.

to properly degrade or eliminate foreign or toxic materials, such as pesticides. Therefore, use extreme caution when making pesticide applications in rooms where elderly people sleep or spend long periods of time; whenever possible, avoid treating these places. In other areas, use a low toxicity and low volatility pesticide. Apply this as a spot treatment only as necessary. Select alternate methods of control whenever possible, and always augment pesticide use with other pest control techniques so the amount of pesticide used can be reduced.

People who are acutely ill, or those who suffer from conditions such as diabetes or alcoholism, or those who have allergies or respiratory disorders, including asthma and emphysema, may be more sensitive to pesticides. Medications used to treat illnesses may influence the effects of pesticide exposure. Provide persons who are ill or using medications with the name of the pesticide you plan to use and ask them to contact their physicians for advice.

Pets housed in or near residences or other buildings include several types of mammals, birds, reptiles, amphibians, and fish. Associated with pets and domestic animals are their food and water supplies, bedding, pens, equipment and toys.

Most animals are susceptible to injury by pesticides, even some types that are applied at low doses. Fish and birds are among the most susceptible. Cats are very sensitive because they are metabolically unable to detoxify many types of pesticides. Young animals and older or sick animals may be affected by lower pesticide doses than adult or healthy animals. Cats and dogs lie and sleep on the ground and other surfaces that may have been treated. They groom and clean themselves by licking, which increases their potential for exposure even when small amounts of pesticide have been used.

To provide protection for pets and domestic animals, remove them from the area before applying a pesticide.

Keep animals away until the spray dries and the area is well ventilated. Do not apply pesticides on or near animal food or water. If the animals return to the treated area, remove their flea collars. Discontinuing any on-pet flea or tick treatments may also be necessary.

Protecting Pets and Domestic Animals

Pets or domestic animals can be the source of some pest problems. For instance, dogs and cats usually bring fleas inside; dogs may also carry in ticks. Animal manures provide food and breeding sites for several fly species. Pet or livestock food or food left in an animal dish or feeder can attract mice and rats as well as cockroaches, flies and ants. An animal's water dish may provide the water some pests, such as mosquito larvae, need. Therefore, when performing pest management in an area where pets or livestock are kept, look for these types of conditions. Evaluate and, if necessary, suggest modifications of the feeding routine, housing arrangement and sanitation practices to reduce pests.

Applicator Safety

Safety risks for applicators working in buildings or enclosed areas are compounded by hazards such as electrical equipment, possibility of explosions and confined work areas. Learn to recognize hazards in the application site that could cause injury and know the symptoms of poisoning. Avoid pesticide exposure by wearing required or recommended protective equipment. Maintain, clean and store protective equipment carefully to keep it in good condition and to ensure that it provides optimum protection (Table 3-2).

Fire, Explosion and Electrical Hazards

Fires, explosions and electrical hazards can be found in residential, industrial and institutional settings and other confined areas. Before using a pesticide, examine the application site for hazards. For example, never apply a pesticide dissolved in oil or petroleum solvent in an enclosed area if there is any source of spark or flame, such as functioning electrical motors, wall switches, appliances or pilot lights; before making an application, shut off electric and gas services to the treatment area. Avoid the use of aerosols in wall voids near hot water pipes; heat from these pipes can ignite solvents and cause a fire. Do not use dust in an enclosed area if there is an ignition source, as any airborne dust at the right concentration can explode. Boric acid dust is capable of extinguishing a pilot light, which could create an explosion hazard due to escaping gas (most new gas appliances are equipped with safety shut-off devices or igniters in place of pilot lights). Electrical contacts and flexible copper can be corroded by dusts. Do not apply dusts, such as boric acid, to computers or flexible copper gas lines.

Do not use a water-based spray around electric appliances, outlets or switches unless the power has been shut off. Water conducts electricity, so you risk electrocution if the spray touches a live power source.

Power tools and other electrical equipment that you may use during a pest control operation can also create hazards. Wiring in older buildings may not accommodate heavy-duty electrical equipment. Before connecting equipment, use a circuit tester to make sure the outlet is correctly grounded. Check the wiring size and the fuse or breaker box to be sure that the system can handle the electrical demand of the equipment being used. If the circuit is not protected with the correct size fuse or circuit breaker, or if wiring is too small, an overload could heat the wiring and start a fire. Inadequate grounding can cause a fatal electric shock; prevent this hazard by using a ground fault interrupter (GFI).

Working in Confined Areas

Confined areas present special hazards to persons making a pesticide application. Confined areas may be attics, crawl spaces beneath buildings, storage areas, closets, small rooms and other places with poor ventilation. Hazards include inhaling the pesticide being applied and coming in contact with treated surfaces. Cramped areas may be uncomfortably hot due to poor air circulation. High temperatures may increase your exposure potential, because sweating and high temperatures accelerate the rate of skin absorption of some pesticides.

Reduce exposure hazards when working in confined areas by wearing personal safety equipment (Figure 3-5). Whenever possible, increase ventilation in the treatment area by opening windows or using a fan to bring in fresh air. Always begin the application from a point furthest from the exit; never walk or crawl through freshly applied pesticide.

To avoid breathing fumes, wear an approved pesticide respirator. Be sure it seals well around your face and is in good working condition. A cartridge or canister-type respirator must be worn whenever a Category I or Category II pesticide is being used in confined areas. Applicators with beards or long sideburns must use a powered cartridge respirator, because facial hair prevents adequate sealing of conventional respirator face masks. When atmosphere monitoring equipment indicates that an oxygen deficiency condition exists, or when applying a fumigant, a supplied-air respirator is required.

Prevent skin or eye contact with spray residue or vapor. Always wear a long-sleeved shirt and full-length pants, coveralls or lightweight spray suit when making an application. Protect your hands with waterproof gloves and use a face shield or goggles to prevent spray or dust from getting into your eyes. Check the pesticide label for the minimum protective clothing requirements.

Pesticide Drift

If pesticides are not carefully applied, they may drift beyond the treatment site and become deposited as unacceptable residues on surfaces not intended to be treated. These residues can possibly endanger nontarget organisms. Residues from improper application or rinsing of equipment may also result in contamination of surface or groundwater.

Preventing Drift or Unwanted Exposure

Do not use dusts in outdoor locations. To prevent drift when applying liquid sprays, use low pressures and large-nozzle orifices. This prevents formation of small droplets

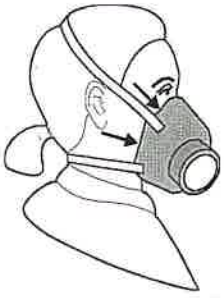
Properly Fitting Cartridge Respirators

ISOAMYL ACETATE (banana oil) FIT TEST*

The chemical isoamyl acetate, commonly referred to as "banana oil," is available from major chemical suppliers and is widely used to check respirator fit. Its odor is easy to detect and the chemical can be used with any pesticide respirator equipped with organic vapor cartridge or canister.

When conducting a fit test, it is important to know that some brands of respirators are available in small, medium, and large sizes. If possible, have several different sizes available during the test to ensure proper fit. Try respirators from different manufacturers since one brand may fit better than others.

If a respirator does not fit properly, the applicator will not be adequately protected. Therefore, be sure to follow the test procedures outlined below:



1. Be sure there is no banana oil odor in the test area that may influence the wearer's ability to detect its presence. Once a respirator is selected, have the wearer adjust it until there is a good face-to-mask seal.
2. Saturate a piece of cotton or cloth with banana oil. The person performing the test should wear rubber gloves and avoid skin contact with the wearer.

3. Pass the saturated material close to the respirator in a clockwise and counter-clockwise motion. Have the wearer stand still and breathe normally and then deeply. If the wearer smells banana oil, readjust the respirator or select a different size or style before starting again.
4. If the odor cannot be detected while the wearer is standing still, have them perform side-to-side and up-and-down head movements. Also have the wearer talk loudly enough to be heard by someone standing nearby. Then have the person make other movements, such as bending over, that may occur during spray application.
5. If the banana oil odor cannot be detected during the above movements, it indicates a satisfactory fit. Seal the respirator in a plastic bag marked with the wearer's name. Keep a record of when the fit test was conducted, along with the size and brand of respirator selected for each user.

*Adapted from "A Guide to the Proper Selection and Use of Respirators", Zoecon Corporation

subject to drift. Never make an outdoor application of a liquid spray when the wind is blowing faster than five miles per hour. If there is a slight wind, select a formulation or adjuvant that reduces drift. Be especially careful if you are spraying near fruit trees or vegetable gardens, flowers, laundry being air dried, cars, windows, dark surfaces that may spot, pet or livestock food and water containers, fish ponds, bird baths, swimming pools, saunas, spas or outdoor furniture. Avoid outdoor applications that may drift to children's play areas, sandboxes, swing sets, or lawns and shrubbery that children contact.

Do not apply a pesticide outdoors where residues can be carried into a well, stream, pond or other water source. Never drain or wash application equipment where runoff into sewers, sinks, sumps or drainage tiles can occur.

When applying liquid or dust inside, keep it away from air ducts, fans or blowers to prevent the material from being blown around.

Characteristics of Treated Surfaces

Treatment sites may have surfaces whose characteristics must be evaluated before applying a pesticide. Depending on the type of surface, a pesticide can be absorbed and rendered ineffective, or the surface may be stained or etched. Concrete, for example, is porous and tends to absorb liquid sprays, reducing the amount of residue on the surface available to control target pests.

Floor coverings such as linoleum, tile and carpeting can be stained or etched by some pesticides or solvents. Certain wallpapers and carpets contain dyes that may run, dissolve or change colors if exposed to some pesticide components. Paint and other finishes used on walls or woodwork may also react with these chemicals to produce spotting or discoloration. Fabrics of all types, and the dyes used for patterns and color, may also react, affecting wear or causing a stain or color change. A soiled fabric may react differently from a clean one. Fabrics also can absorb a liquid pesticide, reducing pest control effectiveness. Dust formulations leave an unsightly residue if applied to surfaces of furniture, woodwork, fabrics and other items in the treatment area.

Preventing Problems

Stains or color changes may be caused by an excessive dose or by certain application techniques. The formulation type may affect staining or spotting. A soiled or greasy surface may increase staining, spotting or absorption. Paint that has been recently applied and not fully cured has more of a tendency to spot.

Whenever possible, first apply a pesticide to an inconspicuous area, such as a closet, and allow the pesticide to dry for several hours to observe the reaction. Be careful when treating upholstery, furniture, drapes or lower wall surfaces with a pesticide. Lower wall surfaces are more likely to be soiled, which may enhance staining or bind the pesticide to make it less effective. Read and follow label directions and precautions carefully to avoid staining, spotting, visible residues and pesticide deactivation. Thoroughly clean the application equipment before adding a pesticide to prevent

Item	Uses/Problems	Maintenance
PROTECTIVE EYEWEAR		
Goggles	Suitable for most mixing and application jobs. Lenses scratch easily. May fog up. Choose goggles with nonabsorptive headband.	Clean daily with soap and water. Replace scratched lenses and worn straps.
Safety glasses	Must have brow and side shields. More comfortable than goggles. Do not provide as much protection as goggles. Available with tinted lenses.	Clean daily with soap and water. Replace when lenses become scratched.
Faceshields	Suitable for mixing but not for most application situations. Scratches easily. Must have non-absorbent headband.	Clean daily with soap and water. Replace when plastic faceshield becomes scratched.
PROTECTIVE HEADWEAR		
Plastic hard hat	Must have nonabsorbent head band.	Clean daily with soap and water.
Hood on waterproof jacket	Should not be removable. Must be unlined.	Clean daily with soap and water.
PROTECTIVE CLOTHING		
Woven long-sleeved shirt and long pants	Minimal protection but should be worn when more protection not required. Avoid wetting with liquid sprays.	Launder daily with hot water and liquid detergent.
Woven coveralls	Minimal protection. Can be removed easily if contaminated Protects clothing underneath. Avoid wetting with liquid sprays.	Launder daily with hot water and liquid detergent.
Disposable coveralls	Several types offering different types of protection. Unlaminated materials offer similar protection as woven materials. Laminated materials offer protection similar to waterproof materials.	Generally not reused. Throwaway after each day or launder with hot water and liquid detergent.
Waterproof rainsuit	Maximum protection. Must have attached hood. Must be unlined or have nonabsorbent lining.	Launder daily with hot water and liquid detergent. Check daily for cracks and tears.
Waterproof gloves and boots	See previous chart for suitable materials. Gloves should be unlined.	Wash gloves daily with mild soap and water. Check daily for holes and cracks.

a possible reaction between the pesticide and contaminants in the equipment. These contaminants may cause stains or other adverse effects.

When two or more pesticides are mixed, additional problems associated with pesticide compatibility may appear. Check the compatibility of pesticide mixtures before application.

Odor Problems

Many pesticides have odors that can be detected during and after application. Odors are usually strongest when pesticides are first applied. In confined areas, odors may become overpowering and objectionable. They can cause nausea or headache, initiate asthma or other breathing difficulties, or trigger other medical or anxiety-related symptoms.

An odor may be a chemical characteristic of the pesticide or its solvent or it may be a substance added to the pesticide as a warning agent to reduce chances of injury. Reduce problems associated with odors by (1) using only the application rate stated on the pesticide label, (2) applying the pesticide in localized areas or as a spot treatment whenever possible, (3) using a low-odor formulation if available and if appropriate, (4) increasing ventilation to the application area by opening windows and doors or using fans, and (5) applying the pesticide during periods when the building is not occupied.

An odor may also be caused from a reaction between the pesticide and surfaces that have been treated. Before applying any pesticide in a confined area, read the pesticide label to determine if any of the chemicals in the formulation will react with treated surfaces to produce an odor.

Transporting Pesticides

Pesticides must be transported with special care to prevent spills or accidents that might possibly injure people and animals or damage the environment. A pesticide spill on a roadway can result in serious problems.

Pest control service vehicles such as pickup trucks or vans are generally used to carry pesticides and application equipment to work sites. Some pesticides may be in original containers or service containers; others may be in a spray tank or application device. No matter what form they are in or how they are contained, pesticides transported on public roads are classified by regulatory agencies as hazardous materials. Unused spray material may be classified as a hazardous waste.

Figure 3-5. Reduce exposure hazards by wearing the appropriate personal protective equipment.

Classification as a hazardous waste greatly complicates the manner in which pesticide materials can be transported, stored and disposed.

Government agencies regulate hazardous material and hazardous waste transportation on public roads. Transportation regulations also require that certain vehicles be equipped with placards indicating the class of hazardous material carried. Vehicles may be subject to inspection by the Tennessee Department of Agriculture.

During transport, keep undiluted pesticides in their original containers or in approved, labeled service containers. If a container has previously been opened, be sure it is tightly resealed before transporting. Carry diluted pesticides in approved containers and label them according to state and federal regulations. Application equipment or service containers containing pesticides must be labeled with the name of the pesticide, the toxicity signal word from the original container, and the name and address of the person or company responsible for the container. It should also bear the statement "KEEP OUT OF THE REACH OF CHILDREN."

During transport, secure all pesticide containers and application equipment to avoid spills or container damage. Use sand bags, blocks, ropes or straps to prevent movement. The vehicle should be equipped with an emergency spill control kit, including a supply of absorbent material, a special container for holding waste and a quantity of clean water. If a spill occurs, no matter how small, clean it up immediately.

Lock the area within the vehicle where pesticides are carried to keep children or unauthorized adults out when the vehicle is unattended (Figure 3-6). Also, lock tanks containing diluted pesticides, or store tanks and other equipment containing pesticides in a locked area on the vehicle that is separate from food, feed and passengers.

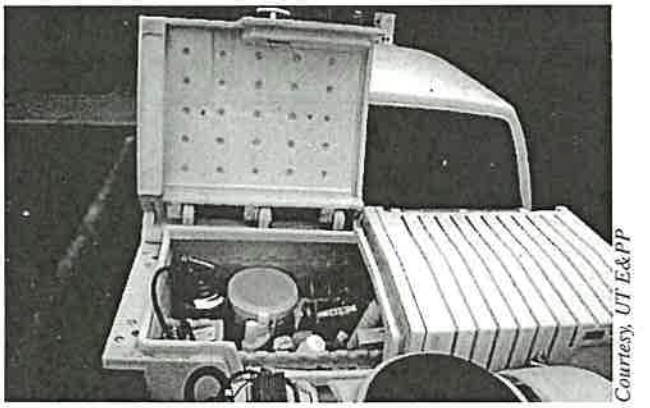


Figure 3-6. Lock the area within the vehicle where pesticides are carried to keep children or unauthorized adults out when the vehicle is unattended.

Review Questions

1. Most pesticides should not be stored for longer than two years.
   - A. true
   - B. false

2. Pesticide containers must be _____ before they can be disposed of in a class 1 disposal site.
   - A. certified
   - B. incinerated
   - C. inspected
   - D. triple rinsed

3. The most common pesticide types used in and around structures are _____.
   - A. insecticides and rodenticides
   - B. insecticides and fungicides
   - C. insecticides and nematicides
   - D. rodenticides and herbicides

4. Pesticides dissolved in a liquid are called _____ _____.
   - A. concentrates
   - B. solutions
   - C. formulations
   - D. mixtures

5. Wettable powder formulations can be abrasive to nozzles.
   - A. true
   - B. false

6 It is rarely necessary to use respiratory protection when applying dusts.
   - A. true
   - B. false

7. Ant baits should be _____-acting and fly baits should be _____-acting.

A. slow, fast
B. fast, slow
C. fast, faster
D. slow, slower

8. Facial hair, such as a beard, helps to create a tight seal when wearing conventional respirators.

A true
B. false

9. Pesticides should be applied in or near air conditioning or heating vents to aid in distribution of the chemical.

A. true
B. false

10. When in transport, application equipment containing pesticide needs to only be labeled with the statement "Keep out of reach of children."

A. True
B. False

11. When a vehicle is unattended and pesticides are present, the pesticide must be _____.

A. brought back to a company storage site.
B. marked "Do not touch"
C. locked in an area within the vehicle.
D. none of the above.

12 _____is often used to check cartridge respirator fit.

A. Isoamylacetate
B. Orange oil
C. Boric acid
D. Pyriproxyfen

Answers: 1. A, 2. D, 3. A, 4. B, 5. A, 6. B, 7. A, 8. B, 9. B, 10. B, 11. C, 12. A

Chapter 4 Pests on or near food

Cockroaches, ants and flies are some of the most common pests found on or near food in buildings. Successful suppression of these pests is based on understanding their habits so that control methods can be directed to susceptible life stages. To accomplish this, these insects must be correctly identified. General descriptions are included in the following section, along with drawings or photographs of some of the more common species. For more complete information on identifying cockroaches, ants or flies, refer to some of the identification resources listed in the Appendix at the end of this manual.

Ants

As a group, ants are the most difficult household pests to control. In a recent survey, pest control technicians indicated they had more callbacks due to ants than any other insect. Too often our first response to a pest problem is to spray. When managing ants, this can lead to disaster. In some cases, such as with Pharaoh ants, spraying ant trails only makes the problem worse. Identification of pest ant species and understanding their biology and management are necessary to successfully control them.

Behavior

Ants are social insects. Their nests or colonies can be found indoors and out, although some species have preferred nesting sites. A nest contains one or more queen ants laying eggs and being cared for by worker ants. Worker ants which are sterile or nonreproductive female ants, tend the queen and brood (eggs, larvae and pupae) and forage for food. Foraging ants can invade households from colonies outdoors.

Nests often can be located by following "trails" of foraging ants. Indoors, ants nest almost anywhere. For instance, Pharaoh ants readily nest in attics, appliances, linens, heating ducts, wall voids and light switches or fixtures. Killing foraging ants rarely solves an ant problem in the home because the colony remains unaffected.

During certain times of the year, most species produce reproductives, winged male and female ants, that leave the nest to mate and establish new colonies. When winged ants swarm in the home, their colony is likely to be located somewhere inside. Mating flights often occur on a warm day after a rain. Although ants are not closely related to termites, the winged forms of these two insects are often confused. Winged ants can be distinguished from termites by several characteristics (Figure 4-1).

The presence of winged ants outside, such as around porch lights, should not be a concern, although in high numbers they can be a nuisance. Most winged forms are unsuccessful in establishing a new colony. Turn off porch lights or use yellow "bug" lights to make these locations less attractive to them.

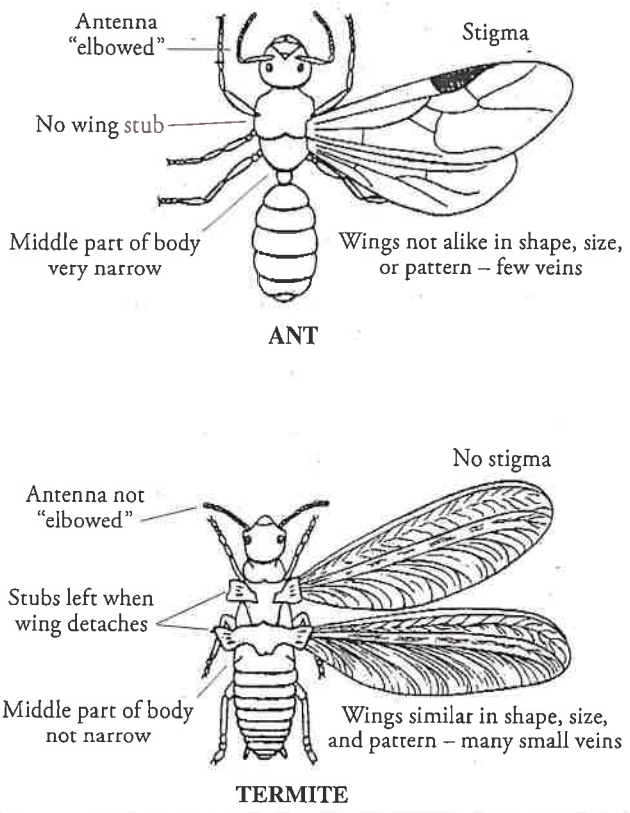


Figure 4-1. Comparison of a winged ant and winged termite.

Ants form new colonies in several ways. Most are started by a newly mated winged reproductive, now called the queen ant. After finding a suitable nesting site, the queen loses her wings and begins laying eggs, which hatch into legless, grub-like larvae. The queen feeds the larvae as they develop through several stages. They molt and grow between each stage. Afterward, they form pupae and soon emerge as adult ants. Once worker ants have developed, the queen no longer needs to care for the brood.

Some ant colonies have more than one queen, and mating may occur within the nest without swarming. These ants form new colonies when one or more queen ants, along with

some workers and brood, leave the nest and move to a new location. Frequently, entire colonies move from one nesting site to another almost overnight. Particularly during very wet or abnormally hot and dry weather, ant colonies whose nesting areas are flooded or those that lack food and water often migrate indoors.

Foraging workers of some ants establish temporary chemical (pheromone) trails that help other ants find food and water. These species can "recruit" other ants to a resource quickly and in high numbers. Food is brought back to the colony and fed communally among the other members of the colony, including the queen(s) and brood, a process called trophallaxis. Baiting to control ants takes advantage of these foragers to bring the toxin-laced food to often inaccessible colonies.

Ants can be a nuisance as well as a health threat. Worker ants foraging for food and water become a concern when they infest food or other items in the home. Although most ants consume a wide variety of foods (they are omnivorous), certain species prefer some types of foods and some even change their preferences over time. Species of ants that sting, such as red imported fire ants, can endanger young children, confined pets and bedridden people. Pharaoh ants can carry disease-causing organisms on their exoskeleton and therefore are a problem in hospitals and healthcare facilities. Identification of the ant is important to determine its pest status and the control procedures needed.

Common indoor ant species

Throughout the world, there are more than 8,804 species of ants. Carpenter ants and odorous house ants are common household pests in Tennessee. Identification characteristics and some habits of the other pest ants are also provided. To understand the words used to identify pest ants, see Figure 4-2.

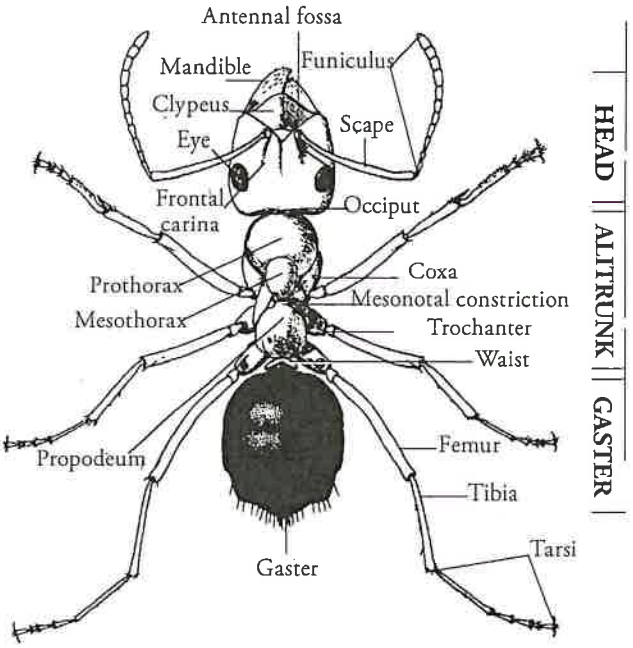


Figure 4-2. External morphology of the Allegheny mound ant (Vail et al. 1994).

Carpenter Ants, *Camponotus sp.*

Identification Approximately 10 species of carpenter ants live in Tennessee. The largest, the black carpenter ant, Camponotus pennsylvanicus, is found primarily outdoors in wooded areas and is responsible for many structural infestations. Most other species are red and black, although some are golden. Worker ants range from 1/8 to 1/2 inch long. Allegheny mound ants and field ants, Formica spp., are often confused with carpenter ants. Carpenter ants can be distinguished from most other large ant species by an evenly convex thorax that bears no spines (Figure 4-3). Also, the waist has a single node or bump. Although these ants bite, they do not sting.

Carpenter ants are wood-destroying insects and are covered in more detail in the wood-destroying organisms (WDO) licensing manual. To manage a carpenter ant infestation, the technician must be under the supervision of an operator licensed in wood-destroying organisms. Carpenter ants are mentioned in this manual to help distinguish them from other species covered under the GRC license.

Nesting and foraging habits Foraging worker ants in the home can be a nuisance. Carpenter ants usually nest in dead wood, either outdoors in old stumps and dead parts of trees and around homes (in fences, firewood, etc.) or in moist wood indoors (around sinks, bathtubs, poorly sealed windows and door frames, roofs, gutters, etc.). Flying carpenter ants indoors do not always indicate the presence of the parent or main colony. One study indicated that the black carpenter ant had two to six nest sites. Ant colonies may also be located in cracks and crevices between structural timbers, but the ants can also tunnel into structural wood to form nesting galleries. However, damage is often limited, because the ants tunnel into wood only to form nests and do not eat wood. Galleries excavated in wood to produce nesting sites can weaken structures. When produced by carpenter ants, nesting tunnels usually follow the grain of the wood around the annual rings. Tunnel walls are clean and smooth. Nests can be located by searching for piles of sawdust-like wood scrapings (frass) under exit holes. These piles accumulate as the nests are excavated and usually also contain parts of dead colony members. Foraging worker ants leave the nest and seek sweets and other foods such as decaying fruit, insects and sweet exudates from aphids or other sucking insects.

Life cycle Mating flights of the black carpenter ant usually occur from May to July; however, winged forms of

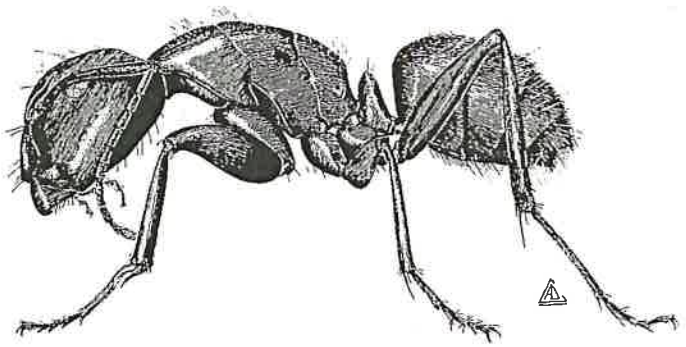


Figure 4-3. Black carpenter ant.

the smaller carpenter ants have been collected from homes as early as February. The newly mated queen starts her colony without the aid of workers. Development time from egg to adult takes about two months. It usually takes 3 – 6 years or a colony population of 2000 workers before the colony will produce winged males and females. Carpenter ants usually have more than one nest site. The parent colony may contain the egg-laying queen, workers, eggs and small larvae, while carpenter ants may form satellite colonies in the home that do not contain the queen. It is necessary to locate and treat the parent colony to prevent further infestation from that colony from occurring in the home. See **PB1599 Carpenter Ants: Those Big Ants in Your Kitchen and Bathroom**, available from your county Extension agent, for further information about carpenter ants.

Odorous House Ants, *Tapinoma sessile*

Odorous house ants are the second most common insect identified at the Urban IPM Lab in Knoxville. "In the mid-South region of the U.S. in northern Mississippi, West Tennessee, and Arkansas, it (odorous house ant) is the primary pest ant invading buildings." (Hedges 1998).

Identification This small black ant, about 1/8 inch long, is easily distinguished from other dark ants by its one-segmented waist with a very flat, barely noticeable node or bump hidden by the abdomen (Figure 4-4). There is another way to distinguish this ant. Crush an ant between the fingers and if it smells of a "disagreeable, rotten-coconut-like" or a banana-like odor, then it's the odorous house ant.

Nesting and foraging habits Odorous house ants forage day and night between the temperatures of 42.8 and 95 F. They can usually be seen actively foraging from March through November, although foraging can occur in December and January. They use guidelines to move from place to place. Guidelines can result from natural objects such as vines, limbs and trunks of trees and shrubs or from artificial objects such as edges of buildings, baseboards, edge of counters/carpets, etc.

Outdoors, odorous house ants feed on living and dead insects, other dead animals, nectar, and excrement (honeydew) from aphids, scales and mealybugs. They prefer to feed on small objects that are between 0.1 – 2 mm. In general, they don't feed on plant oils. Indoors, they can be found feeding on sweets and other household foods and are often found trailing to water. Unlike Argentine ants that usually dominate an area, *T. sessile* has been described as submissive. It avoids other species at a bait even if it was the first ant present; however, it will be more dominant when it outnumbers the other ants.

These ants are opportunistic nesters and can be found outdoors in shallow nests in shady, moist areas such as stones, logs, patios, debris, siding, loose bark, tree cavities, animal nests and bee hives. Indoors, they are usually associated with accessible moisture such as wall voids near pipes and heaters, bathtraps, termite-damaged wood, beneath carpets and toilets.

This ant does not spend much time in one place. In one study, the average number of days that a colony remained at a nest site before moving was 23 days. These ants can often be seen moving brood from one nest to another. Why do they move so often? Some speculate it's to avoid shading, or to find greater soil moisture, to avoid buildup of wastes in the nest, to decrease discovery by natural enemies, because nest sites are short-lived, to decrease competition or to respond to changes in the weather (rain, drought). We have observed that odorous house ants often move indoors during periods of heavy rain.

Life cycle This species establishes multiple queen colonies that often reproduce by splitting off from the mother colony; however, some flights do occur. Over the past three years, male odorous house ants collected from lights have been sent to the Urban IPM lab from the end of May through the end of June. Development times for each stage are: 11 – 26 days for eggs, 13 – 29 days for larvae and 10 – 28 days for pupae. Overall, time for egg to adult will range from 5 – 9 weeks in the summer to 6 – 7 months through the winter.

Pharaoh Ant, *Monomorium pharaonis*

The Pharaoh ant is another ant found indoors in Tennessee. They are also called "sugar ants" or "piss ants." Pharaoh ants are considered pests because they:

1) are a nuisance by their mere presence;
2) can enter sterile packages, wound dressings, intravenous solutions and tubing;
3) have the potential to carry disease-causing organisms such as *Salmonella, Streptococcus, Staphylococcus, Clostridium* and *Pseudomonas*; and
4) can short electrical equipment such as computers.

As you can see, Pharaoh ants pose a significant health risk when found in hospitals and similar institutions. Pharaoh ants do not sting and usually do not bite, but when large numbers of these ants are handled, such as in sheets of a bedridden person, they can inflict pain with their bite. The pain is not as severe as a fire ant sting.

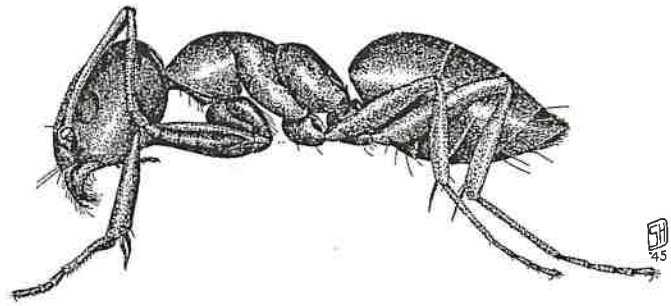


Figure 4-4. Odorous house ant.

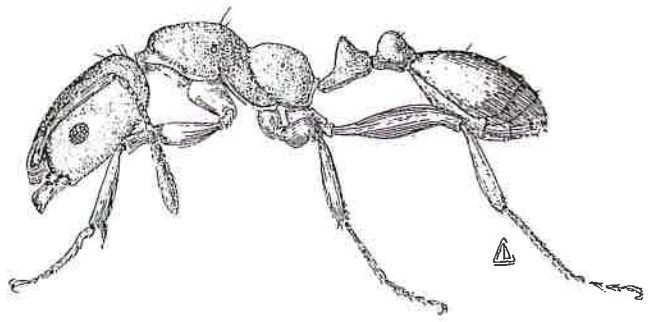


Figure 4-5. Pharaoh ant.

Identification A small ant, the Pharaoh ant is 1/16 inch long and is yellow or orange with the end of the abdomen darkened. It has a two-segmented waist and a 12-segmented antennae with a three-segmented club (Figure 4-5). Newly emerged adult Pharaoh ants are very light-colored. Often these ants are confused with thief ants, which are light in appearance, but thief ants have a 10-segmented antenna with a two-segmented club.

Nesting and foraging habits Pharaoh ants are omnivorous, feeding on sweets, jelly (particularly mint apple jelly), sugar, honey, cakes and breads, and greasy or fatty foods (peanut butter, pies, butter, liver and bacon). Nests are rarely found outdoors; however, almost any crack and crevice found indoors (interior wall voids, between the paper of the insulation and the interior surface [walls, ceiling and attics], areas under or behind window sills, toilets, sinks, switch plates, lights and voids in aluminum window and door frames, etc.), particularly close to sources of warmth and water, are subject to nesting by Pharaoh ants.

Life cycle A worker ant develops from an egg (5 to 6 days) through several larval stages (22 to 24 days), a prepupal stage (2 to 3 days), a pupal stage (9 to 12 days) to an adult ant. Development from egg to adult takes from 38 to 45 days (4 days longer for sexual forms). Colonies consist of one to several hundred queen ants, sterile female worker ants, periodically produced winged male and female reproductive ants (sexuals) and brood (immature stages including eggs, larvae and pupae).

These ants do not swarm. Colonies multiply by "budding," in which a large part of an existing colony migrates, carrying brood to a new nesting site. As few as five workers and 50 pieces of brood can result in greater than 10,000 workers within a little more than a year. This means that workers and brood transported between folds of linens, cardboard boxes, notebooks, name tags, etc. can easily initiate a new colony. A mature colony can contain from 10,000 to many hundreds of thousands of workers. Because Pharaoh ant colonies are hidden and can occur in virtually any crack or crevice, baiting is the best way to get an insecticide back to the colony.

Imported Fire Ant, *Solenopsis spp.*

As of June, 2007, imported fire ants infest 49 southern counties in Tennessee. They build hills or mounds in open areas where the colonies live, although colonies occasionally occur indoors and in such structures as utility housings and tree trunks. When a mound is disturbed, worker ants mount a rapid defense, quickly running up vertical surfaces. Worker ants range from 1/8 to 1/4 inch long, have a ten-segmented antenna with a two-segmented club and are dark or reddish brown (Figure 4-6). Queen ants are larger (3/8 inch) and lose their wings after mating.

Sterile female fire ant workers can sting repeatedly. First they bite; then, while holding onto the skin with their jaws, they inject venom with stingers at the end of their abdomens. The unique venom produces a fire-like burning sensation. Most people react by developing a whitish pustule or fluid-filled blister at the sting site after a day or two. Those hypersensitive to the stings should be prepared for a medical emergency if stung. Most people can tolerate multiple stings, but may have problems with secondary infections at the sting sites.

Fire ants are considered to be medically important pests. They are omnivorous and eat insects, other invertebrates and other food sources. Their predatory activities suppress populations of ticks, chiggers, caterpillars and other insects.

Pavement Ants, *Tetramorium caespitum*

These ants are 1/8 inch long, with a brown to black body. The waist has two nodes or bumps. Pavement ants are most easily identified by the narrow, parallel furrows in the head and thorax and a small pair of spines on the propodeum (Figure 4-7). Nesting sites include soil beneath stones, pavement or slabs. Nests can also be located in walls, under floors or in insulation. Meat, grease, dead insects, seeds and sweets all make up the diet of the pavement ant. Baiting is effective for this ant. Swarms from outside nests occur in the spring, but may occur continuously if the nest is located indoors. If repeated swarming occurs indoors, it may be necessary to inject an insecticidal dust into the wall void from where the winged forms emerge. The winged forms may not feed before a flight, so baits would not be effective for them.

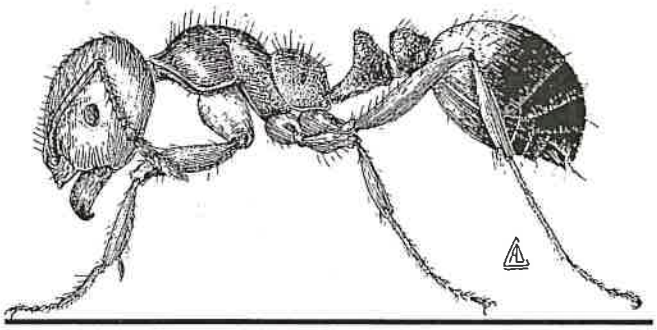


Figure 4-6. Imported fire ant.

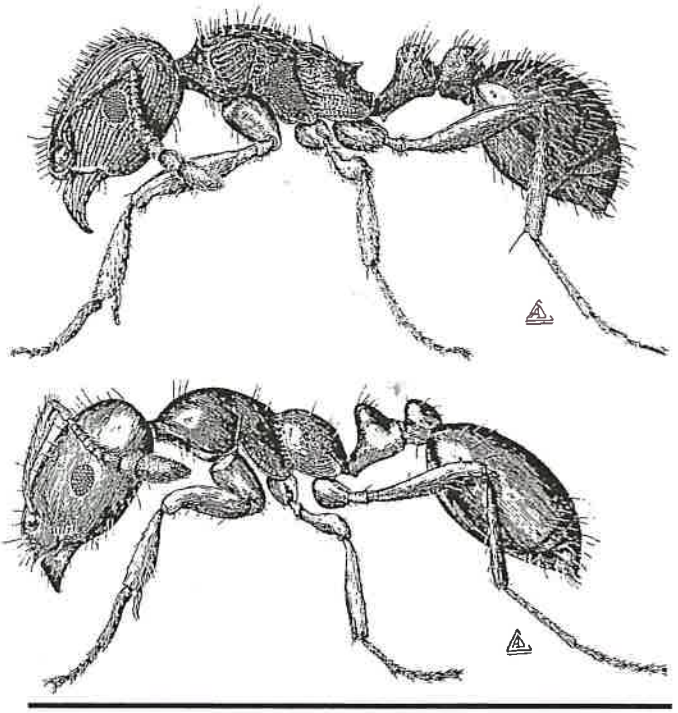


Figure 4-7. Pavement ant (top) and little black ant.

Little Black Ants, *Monomorium minimum*

These are small (1/16 inch), slow-moving, shiny black ants and are similar to Pharaoh ants except for their color (Figure 4-7). Nests are located in soil, rotten wood, woodwork or masonry of houses. Workers feed on insects, honeydew produced by sucking insects such as aphids, sweets, meats, bread, grease, oils, vegetables and fruits.

Yellow Ants, *Acanthomyops interjectus* **or** *A. claviger*

"Citronella ants," as they are often called, smell of lemon when crushed. They are relatively large, about 3/16 inch and are yellow to yellow-red. A single node or bump is found on the waist (Figure 4-8). Yellow ants may swarm in early spring, but when a colony is under heated slab, winter swarms may occur. "Termite scares" are often caused when they push soil out of basement cracks. Cracks should be sealed to prevent future entry. Honeydew from subterranean sucking insects makes up the majority of their diet.

Acrobat Ants, *Crematogaster sp.*

Acrobat ants have spines on the thorax and a two-segmented waist that is attached to the top of the abdomen (Figure 4-8). Outdoors, acrobat ants nest under stones, in stumps or dead wood, and occasionally invade the home. Indoors, nests may be found in insulation board, roofing or other damp wood. These ants are named after their ability to hold their heart-shaped abdomen up over their bodies. They feed primarily on honeydew produced by aphids. Nest location is especially important if the nest is indoors. Check moist areas. If necessary, a dust can be injected into the nest. Pest-proofing will keep outdoor nesting individuals from entering.

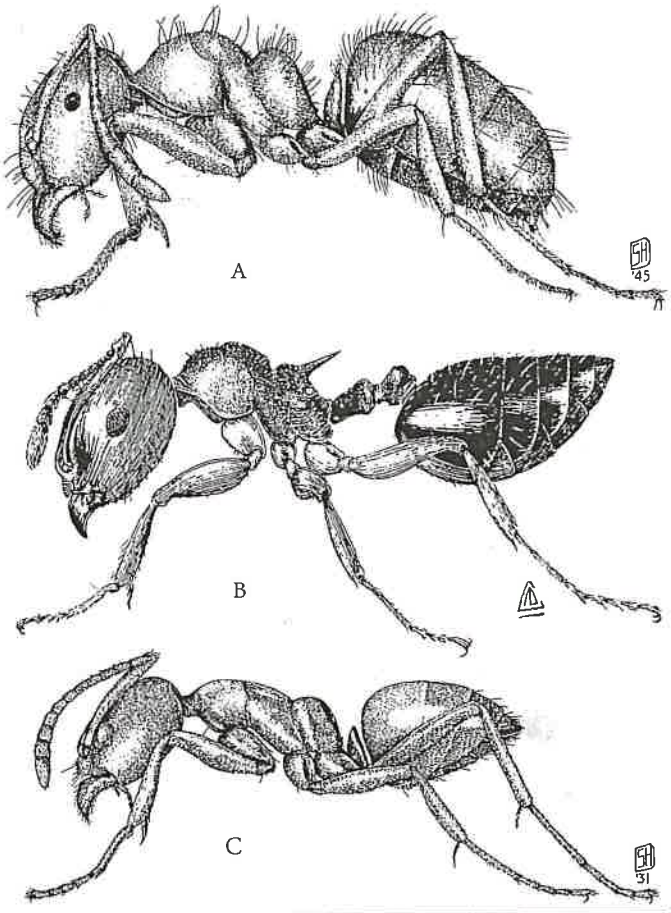


Figure 4-8. Large yellow ant (A), acrobat ant (B) and Argentine ant (C).

Argentine Ants, *Linepithema humile*

Workers of this species are light to dark brown, have a one-segmented waist with a visible node (Figure 4-8) and generally nest outdoors under mulch, along pine tree roots, rocks, etc. They behave very similarly to odorous house ants and also smell when crushed, but have an additional faint musty odor. They have an enormous number of individuals in a colony, because nearby budded colonies are not aggressive toward one another. Argentine ants are not as widespread in Tennessee as they are in other southeastern states. They are uncommon in areas infested by fire ants.

Bigheaded Ants, *Pheidole sp.*

Major worker ants have a relatively large head compared to their bodies. Two sizes (major and minor) of workers will be found in a colony. They have 12-segmented antennae with a three-segmented club (Figure 4-9). Similar in habits to fire ants, they feed on live and dead insects, seeds and honeydew outdoors and greasy food sources and sweets indoors.

Crazy Ants, *Paratrechina sp.*

These fast-moving, dark worker ants have long legs and antennae (Figure 4-9). Although they nest primarily outdoors, they will forage in homes. They are omnivorous, but difficult to attract to ant baits.

How to manage pest ants

Outlined below is a general strategy for managing ants that nest indoors or occasionally enter indoors from outside. A control program is based on accurate identification, sanitation, pest proofing, monitoring and inspection. If the ants are entering from the outdoors, pest-proofing may be all that is needed. If the nest is easily located, then you may choose to directly treat the nest. If the nest cannot be found, which

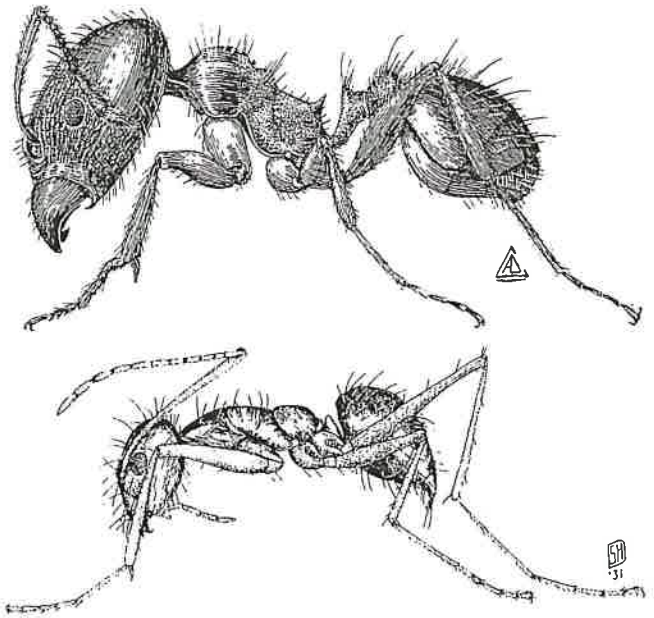


Figure 4-9. Bigheaded ant (top) and crazy ant.

is most often the case, use a bait. Although pest-proofing provides a more permanent barrier, outdoor pesticidal barriers may be used as a supplement when nests are only found outdoors. Fire ants are covered separately at the end of this section. Because carpenter ants are wood-destroying insects, information on their control can be found in the WDO manual. See your local Extension agent for more information on these two ants.

Identification Make sure you properly identify a pest ant before starting a control program. Ants have different food preferences and different behaviors that will directly impact the efficiency of an ant pest control program.

Ants are small and can be difficult to identify. A hand lens is often needed and a microscope with at least 30x magnification is preferred. Specimens can be brought to your local Extension agent for identification. Most identification keys are written for the major workers, so please bring specimens of the wingless workers. Also, ants often have different odors associated with them. Before a specimen is submitted for identification, give it a squeeze (as long as it does not have a stinger!), and add the description of the emitted odor to the specimen form.

Collecting ants for identification Place a small dab of honey or jelly in the center of an index card. Place the card where ant activity has been seen recently. Always place the monitoring cards against edges and never in the middle of a surface. Allow ants to find the food source and recruit other workers. If index cards are placed outdoors, it is best to check the cards within 30 to 45 minutes. Cards left outdoors for a longer period of time may allow other ants to displace the pest ant. Try a natural peanut butter if ants are not attracted to sugars.

Once ants are present on the index card, put the card into a plastic bag and place in the freezer. The cold temperatures will slow the ants down so they can be tapped into a vial containing alcohol and submitted for identification. Don't forget to squeeze a few frozen ants and note any odor produced, before adding them to the alcohol.

Sanitation Ant problems occur in homes and structures primarily because food, water and favorable nesting sites are available there. Meticulous housekeeping eliminates significant ant problems by removing needed resources. Furthermore, ant bait treatments are more effective if alternative food sources for the ants are eliminated as much as possible.

Eliminate sources of moisture and food:

- Fix leaky faucets, remove standing water, etc.
- Replace wet or rotten wood.
- Clean window sills of dead insects that serve as food for ants.
- Remove the food source if ants are trailing to food. Use a mild detergent to wipe ant trails and remove the trail pheromone. (Do not interfere with foraging trails when ants are trailing to baits.)

Pest-proofing — removing access to nesting sites and conditions conducive to nesting and entry Most ants prefer to nest in soil or wood outdoors, but homes offer many favorable nest sites for certain ants. Cracks and holes in brick veneer, wall voids and structural wood close to heat and moisture sources are commonly used. Locate the entry point into the structure, such as a hole in the foundation around plumbing or poorly-sealed windows and doors, and seal these areas to prevent future occurrences. Check potted plants and firewood for ants before bringing them indoors. Keep branches, vines and other vegetation from coming in contact with the house, because ants use them to gain access to the home. Pull mulch, a common nest site, 12 -18 inches away from the foundation of the structure. See Extension **PB1303 Managing Pests Around the Home** (http://www.utextension.utk.edu/publications/pests/default.asp), available from your county Extension agent, for more information on pest proofing.

Monitoring, inspection and nest location Because many nests can occur in one home or other structure, it is important to locate all nests or areas of foraging activity. Monitoring will find small, isolated colonies that otherwise might be overlooked and that could cause re-infestation in the future. Once all areas of foraging activity are located, they can be baited. If the nest can be located, it can be treated directly.

Make a map of the house or other structure. Place index cards containing honey, jelly or unprocessed peanut butter on window sills, sinks and other possible food, water (drains, sinks, counter tops and toilets) and nest sites throughout the structure. In warm weather, placing monitoring index cards outdoors against the structure on window sills, around entrances and exits, water spigots, pipes, AC/heat units, attic vents, etc. may attract the most ants. After placing baits, wait at least 30-45 minutes and return to the monitoring cards.

Follow the ants back to the nest, if possible. Cards may be left in place longer if you need to locate an outdoor nest, but be aware that the food may need replenishing or other ants may displace the ant of interest. If baits are to be used, place a bait station next to the monitoring card prior to disturbing the ants, and gently tap the ants onto the bait station.

Although monitoring, inspection, sanitation and exclusion practices take time and effort, they eliminate undirected, ineffective insecticide spraying indoors. Baiting and ant elimination by nest treatment is more efficient if these practices are used.

Baits Effective bait formulations contain slow-acting pesticides that are collected by foraging worker ants and brought back to the colony, where the pesticide is fed to the other ants, queen(s) and brood. Slow-acting toxicants must remain active after several dilutions. This allows the bait to be transported back to the colony and distributed among all the members. Remember, especially with Pharaoh ants, all the feeding stages of the brood must be affected, as well as the queens and workers. Pupae are not affected by baits since they don't feed, and may be responsible for a small number of workers present after baiting. Baits exploit the forager caste, causing them to introduce the toxicant into a previously inaccessible nest. Because the toxicant works slowly, it is not associated with death in the colony and therefore is continually fed upon.

Bait acceptance is of the utmost importance. If the ants will not feed on the bait, it is useless. Some ants are fickle, especially Pharaoh ants. They are reported to switch feeding

preferences. Prior to placing bait stations, offer several different baits and see which is most attractive to the pest ant. Use information about sweet or grease preferences to select bait candidates. Some of the baits for ant control are listed below by active ingredient (attractant type and trade name): abamectin (oil attractant), hydramethylnon (silkworm attractant), sulfonamide or sulfluramid, boric acid, borax and other borate salts (sweet attractant) and others.

Research has shown that insect growth regulators methoprene, fenoxycarb and pyriproxyfen are effective against Pharaoh ants. Workers are usually not affected and therefore the bait is well distributed throughout the colony. Queens fed these baits fail to produce viable eggs and larval development is terminated. Insect growth regulators take longer to gain control, but are most effective when dealing with large structures, such as hospitals, with extensive infestations. Methoprene, an insect growth regulator, is an active ingredient used for Pharaoh ant control, but it is not commercially marketed at this time. More insect growth regulator baits may be available in the future.

Reasons not to use fast-acting sprays for Pharaoh ant control:

- Sprays may affect bait acceptance.
- Fast-acting sprays may kill the foraging population and the bait will not be brought back to the nest.
- As mentioned earlier, fast-acting sprays may cause colony budding which will further aggravate the problem.
- Fast-acting sprays will kill only a small percentage of the ant colony. In a mature Pharaoh ant colony, only 0.7 – 5.6 percent of the colony forage (Vail 1996).
- Also, fast-acting sprays applied to the exterior of a structure, such as in a barrier or perimeter treatment, may force the ants to forage only indoors, making them more visible.
- "I need quick relief — I can't wait for the baits to work!" said one client. The client sprayed for Pharaoh ants and was still spraying 6 – 8 months later. So put away the sprays and exploit the foraging ants to take the baits back to inaccessible nests.

If ants are still present several weeks after the initial baiting, monitoring and subsequent baiting should be performed again. In storage areas, several bait stations should be placed where they are likely to be encountered by ants introduced from stored materials.

Tips for using baits to control house-infesting ants include:

- Use fresh product and follow directions carefully with the correct number of bait stations or material to treat the infestation.
- Make bait more effective by removing or covering other food sources that compete with the bait's attractiveness.
- Baits can be contaminated during handling. Never let hands that have touched cigarettes touch bait stations, because the odor is repellent. Wear clean gloves when applying baits.
- Before and during baiting efforts, avoid using surface applications of long-acting contact insecticides (often applied to control cockroaches or to ant trails) that would prevent foraging worker ants from being able to reach the bait station.
- Be patient for the baits to work. It may take three to four weeks or more to eliminate some colonies.

Direct nest treatment If nests are indoors and can be located, treat them with an insecticide registered for this use. Be careful; many times the foraging trail disappears into the wall, but does not necessarily indicate the location of a nest. Dust (boric acid, silica gels, synthetic pyrethroids and others) formulations are used for treating nests indoors because they do not stain and generally give longer residual control than sprays. Apply dusts sparingly in thin, even layers in the ant nest area. Holes can be drilled into wood and wall voids and insecticides (dusts, foams and sprays) injected directly into the nests.

If nests are located outdoors, see **Extension PB1739 Managing Imported Fire Ants in Urban Areas**, for techniques of individual mound treatments (baits, drenches, granules, dusts, aerosols or excavation), broadcast baiting and surface applications.

Barrier treatments around the home When ants invade from the outdoors, pest-proofing is a more permanent solution to prevent outdoor-nesting ants from entering the home. Pest-proofing can be supplemented with a chemical barrier if the physical exclusion methods are not as effective as needed. Recall that this may aggravate the indoor-nesting ants, because they may no longer forage outdoors.

Spray a several foot-wide bank or swath of soil around the perimeter of the home and the lower several feet of the house. In the warmer times of the year, spray again if ants are seen in the treated areas. The width of the barrier spray is gradually being shrunk to reduce the potential exposure to clients, pets and the environment. Refer to the pesticide label for width of the barrier spray application.

Barrier treatments can greatly reduce or eliminate ant invasion into the home. Many other pesticides are labeled for perimeter treatments. Wettable powder or microencapsulated formulations are generally more effective on brick veneer homes. Granular insecticide formulations can be used instead of sprays to treat the soil. Read the label to determine if watering the treated area lightly after application to release the insecticide from the granules is needed.

Do not routinely treat the entire premises for ants. Ants are generally beneficial in our landscapes as they scavenge for food and prey on other potential pests such as various caterpillars and chinch bugs. Some ants collect and feed on weed seeds.

Newer active ingredients, such as fipronil, are slower acting and labelled to treat outdoor areas of ant infestation and 1 foot up and out from foundations and have effectively reduced outdoor odorous house ant infestations. To reduce the number of ants found indoors, this should be combined with a bait in the landscape or an effective interior treatment with chlorfenepyr or effective bait.

Managing Fire Ants in Urban Areas

Homes and buildings Fire ants from colonies close to homes and other buildings sometimes forage indoors for food and moisture, particularly during the hot, dry, summer months. Entire colonies occasionally nest in wall voids or rafters, sometimes moving into buildings during floods or drought. They are a nuisance and can threaten sleeping or bed-ridden (indigent) individuals and pets.

Treatment options

- If ants are entering or could enter the home from outdoor colonies, treat mounds near the building using one of the programs described for Home Lawns and Other Ornamental Turf Areas. A contact insecticide with a long residual also can be applied as an outside barrier around the base of the structure. Caulking cracks and crevices may also help prevent ant entry.
- If fire ants are foraging indoors and they do not pose an immediate threat to residents or pets, use a bait labeled for use indoors as directed. Examples are baits containing abamectin, hydramethylnon, fipronil or sulfluramid. Fire ant baits eliminate the colony. Bait products not specifically registered for imported fire ant control may or may not control them.
- Follow trails of foraging ants to colonies located indoors and treat them with contact insecticide dusts or sprays (containing pyrethroids and others) injected into the nest. Treating only ant trails or areas infested with worker ants will not eliminate the entire colony.
- Vacuum indoor ant trails and dispose of vacuum bag immediately. Treat the source colony or entry site of the trail using above options.

Electrical equipment and utility housings Fire ants frequently infest electrical equipment. They chew on insulation and can cause short circuits or interfere with switching mechanisms. Air conditioners, traffic signal boxes and other devices can be damaged. Fire ants also nest in housings around electrical and utility units. The ants move soil into these structures, which causes corrosion, shorting and other mechanical problems.

Note: For safety reasons, an electrician or a licensed pest control operator should treat infested electrical equipment. Specialized products and training are necessary to treat these sites safely and effectively.

Treatment program Turn off all electrical service before starting. With an individual mound treatment method, eliminate colonies around electrical and plumbing casings and housings. Injectable aerosol products containing pyrethrins, or similar products, give rapid control. Hydramethylnon or abamectin baits applied to individual fire ant mounds will provide control in about one week, even if the colony is located within the structure. Do not use liquid drenches, sprays or products that may damage insulation around electrical fixtures. Treatment of a larger area around the electrical structure is optional. Mound and area treatments are described below in the section on Home Lawns and Other Ornamental Turf. Be extremely careful when applying pesticide around water systems and well heads to prevent contamination of wells and ground water. Once ants are eliminated, remove debris and soil from the equipment housings to reduce the possibility of short circuits. For more information on fire ant management in urban areas see **PB1739 Managing Imported Fire Ants in Urban Areas.**

Home lawns and other ornamental turf Treating fire ants in the landscape beyond the 10-foot perimeter of a structure requires an HLT license and is listed here for reference.

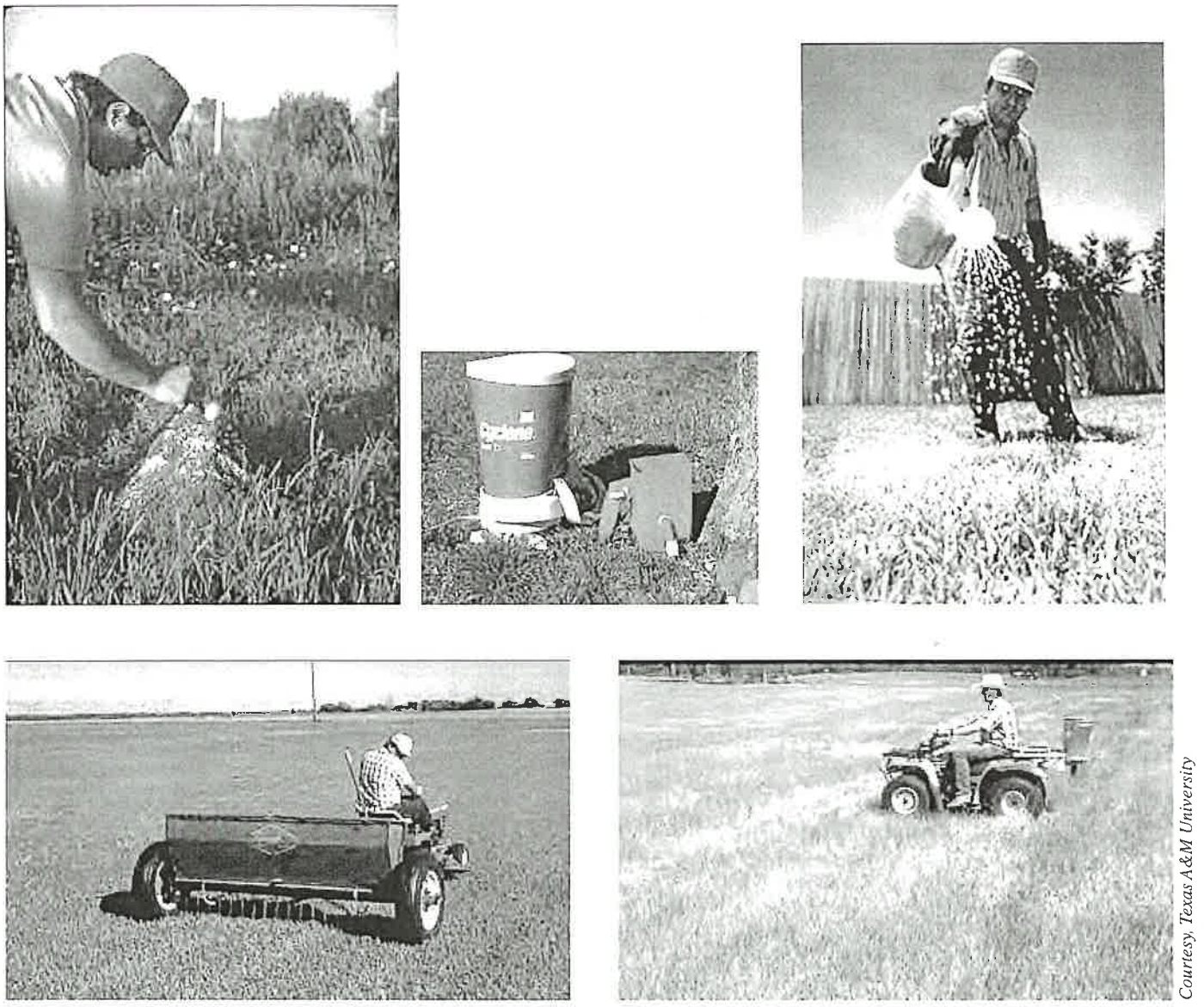
Fire ants commonly infest lawns, school yards, athletic fields, golf courses and parks where they pose a medical threat to people and animals. Their mounds also detract from the appearance of the landscape.

Treatment options

Program 1 — The "Two-Step Method": This program provides long-term ant suppression in ornamental turf and non-agricultural lands, including roadsides. It is best suited to medium-sized or large areas, and the cost is moderate. This approach is not suggested for previously untreated areas with large numbers of native competitor ants and few fire ant mounds (20 per acre or fewer). The goal of this program is to reduce fire ant problems while minimizing the use of individual mound treatments. This program is also suitable for pasture and rangeland, provided that the products selected are specifically registered for use in these sites.

The two steps involve: 1) the broadcast application of a bait product followed by; 2) treating nuisance mounds with a faster-acting individual mound treatment or with a mound re-treatment of the bait:

1. Make a once or twice per year (annual or semi-annual) broadcast application (Figure 4-10) of a bait-formulated insecticide, or use an outdoor bait station product as directed. Most conventional baits are applied at a rate of 1 to 1 1/2 pounds of product per acre, although some products are applied at higher rates. Periodic broadcast applications of fire ant baits provide roughly 90 percent suppression of ants when properly applied. A bait can be broadcast using hand-held, vehicle-mounted or aerial applicators. The speed and duration of ant suppression differs with the product used. Indoxacarb, hydramethylnon and spinosad baits provide maximum control two to four weeks after application, while insect growth regulator (IGR) bait products, i.e., those containing fenoxycarb, methoprene or pyriproxyfen, provide maximum suppression two to six months after treatment, depending on environmental conditions. Abamectin baits act more slowly than hydramethylnon and spinosad, but more quickly than IGR products. Using higher rates of an IGR bait does not eliminate colonies more quickly. For instance, a late summer application produces maximum suppression the following spring. Where there are many mounds per acre (200 or more), a second application after the maximum effects of the first treatment have occurred may be needed, because not all mounds are affected by a single bait application.
2. Wait several days or more after bait is applied, and then treat nuisance ant colonies (such as those in sensitive or high traffic areas) using an individual mound treatment method (see Program 2, Step 1, below). Otherwise, be patient and wait for the bait treatment to work. Any nuisance mounds that escaped the effects of the bait



Courtesy, Texas A&M University

Figure 4-10. Some techniques used to manage fire ants (clockwise from top left): insecticidal dust to mound, examples of manually operated bait spreaders, liquid drench to mound, broadcasting a bait using a spreader mounted to a utility vehicle and granular insecticide to turf/sod.

treatment, or colonies migrating into treated areas, should be treated as needed. In larger areas, this step may be unfeasible and routine broadcast bait treatments alone may provide sufficient control.

Repeat the bait application when ants re-invade the area and mound numbers reach about 20 to 30 per acre. Bait products do not protect against re-invasion by ant colonies from surrounding land or by newly mated queens. Ant populations can fully recover within 12 to 18 months of the last treatment. Low-lying, moist and flood-prone areas are more prone to re-infestation.

Program 2 — Individual Mound Treatments: This approach is best used in small areas of ornamental turf (usually one acre or less) where there are fewer than 20 to 30 mounds per acre or where preservation of native ants is desired. This program selectively controls fire ants, but rapid re-invasion should be anticipated. It generally requires more labor and monitoring than other programs, and is not suggested for heavily infested areas.

1. Treat undesirable fire ant mounds using an individual mound treatment (Figure 4-10). These are applied as dusts, granules, granules drenched with water after application, liquid drenches, baits or aerosol injections. Non-chemical treatment methods, such as very hot water mound drenches, also may be used.
2. Continue treating undesirable mounds that appear, as needed.

Program 3 — The "Ant Elimination Method": This program eliminates nearly all ant species in treated areas. Its effects are more rapid than those of other programs, and re-invasion of treated areas by migrating colonies and newly mated queen ants is minimized as long as the contact insecticide remains effective. However, it is more expensive, uses more insecticide and has greater environmental impact. This approach is frequently used by commercial applicators.

1. (Optional). Broadcast a bait-formulated insecticide in areas where there are many mounds (more than 20 per acre), or individually treat fire ant mounds. Wait two to three days after applying a bait before conducting the next step.
2. Apply a contact insecticide to turfgrass every four to eight weeks, or when ant activity is detected. Liquid or granular products that can be evenly applied to an area are appropriate for this treatment. Some product labels instruct the user to spray "ant hills." Although initial surface treatment may not eliminate ants located deep in mounds, routine reapplication will eventually eliminate colonies.

Program combinations — Any of the three programs can be used on specific sites within a managed area where different levels of fire ant control are desired. On golf courses, for instance, Program 3 might be suitable for high-use areas such as putting greens and tee boxes. In fairways and rough areas, Program 1 may be sufficient. On athletic fields, elimination of fire ants is necessary and Program 3 should be followed. Control programs should be initiated six to eight weeks prior to anticipated use of the athletic fields to insure elimination of ants. People with severe allergies to fire ant stings should follow Program 3 or consider using a bait on a calendar schedule.

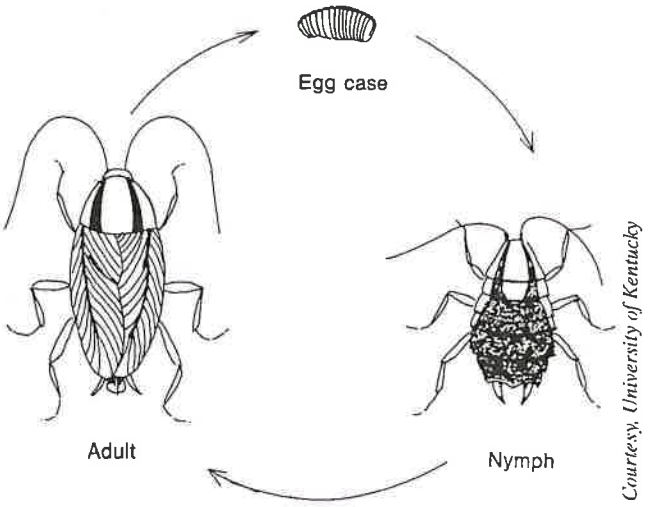


Figure 4-11. Cockroach life cycle.

Cockroaches

Cockroaches are among the most common insect pests found inside buildings. They are especially troublesome where food is prepared and sanitation is lacking. Cockroaches are repulsive to most people simply by their presence. They may contaminate food, kitchen utensils and other items, and they leave an unpleasant odor. Because cockroaches move freely from filth to food, they can transfer microorganisms that cause food poisoning and other illnesses. Many people are also allergic to cockroach excrement and their cast-off skins, resulting in wheezing, watery eyes and skin rashes.

Cockroaches enter buildings in various ways. They are often introduced in produce boxes, beverage cartons, or grocery bags. Species such as the American and Oriental cockroach also gain entry through cracks and openings around windows and doors, and through sewer and drain lines. While cockroaches thrive where sanitation is poor, even the cleanliest home or restaurant can become infested.

Cockroaches are flattened, brownish, fast-running insects, with long, slender antennae. There are three life stages: egg, nymph and adult (Fig. 4-11). The female cockroach produces small, brown, bean-shaped egg cases, called oothecae, that are deposited in out-of-the-way places. Several nymphs emerge from each egg case. Nymphs resemble adults except that they are smaller and lack wings. The nymphs gradually become larger and inhabit the same places as the adults. Cockroaches are prolific breeders.

Cockroaches are more active at night than during the daytime. During the day they generally remain hidden in small cracks and other dark, secluded areas that provide warmth and humidity. At night, they leave their hiding places and search for food. Cockroaches feed on a wide variety of foods and will eat anything consumed by humans. They also feed on such materials as glue, hair, soap, fabrics and filth. Cockroaches readily migrate from one room to another along plumbing and electrical lines and through cracks and openings within walls.

Types of Cockroaches

There are more than 50 species of cockroaches in the United States, but only a handful infest structures in Tennessee (Figure 4-12). Determining which type of cockroach

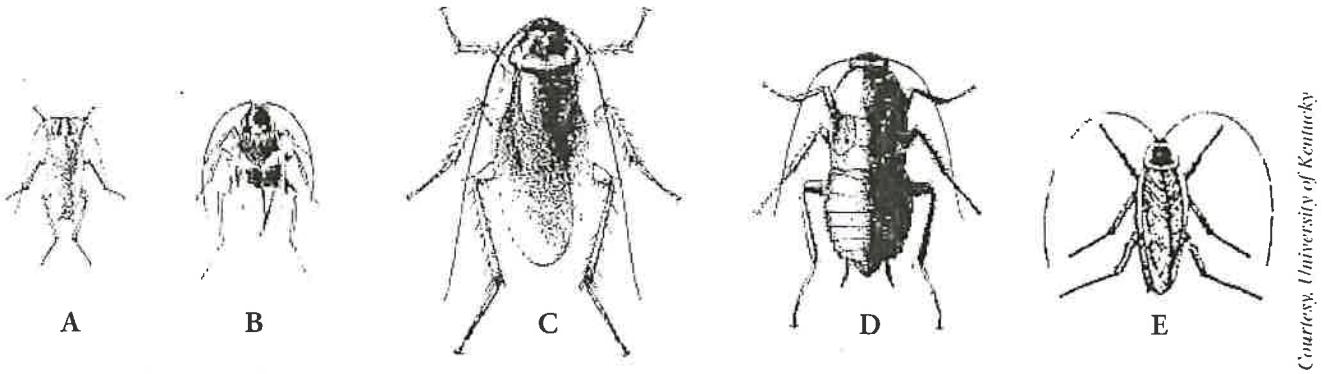


Figure 4-12. Types of cockroaches: German (A); brown-banded (B); American (C); oriental (D); and woods roach (E).

Figure 4-13. German cockroach.

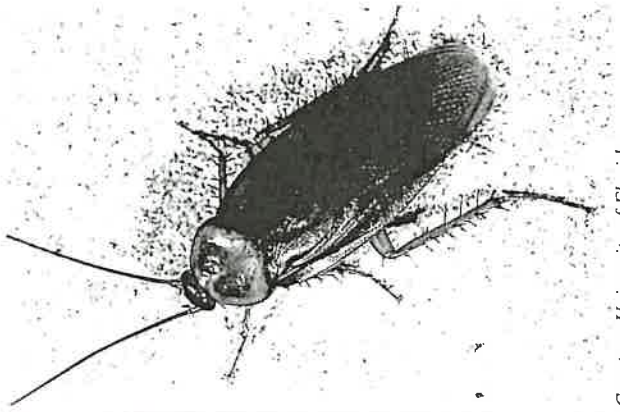


Figure 4-14. American cockroach.

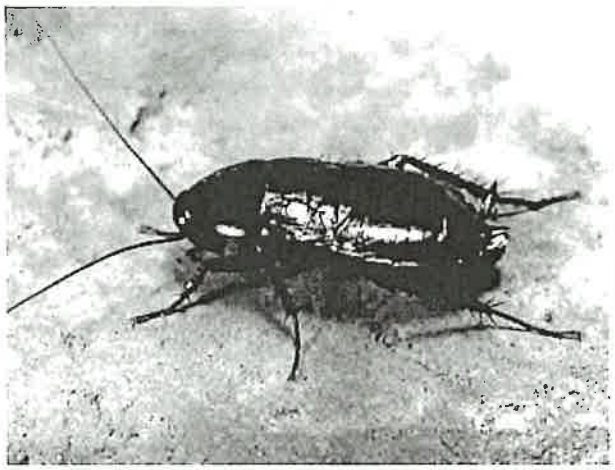


Figure 4-15. Oriental cockroach.

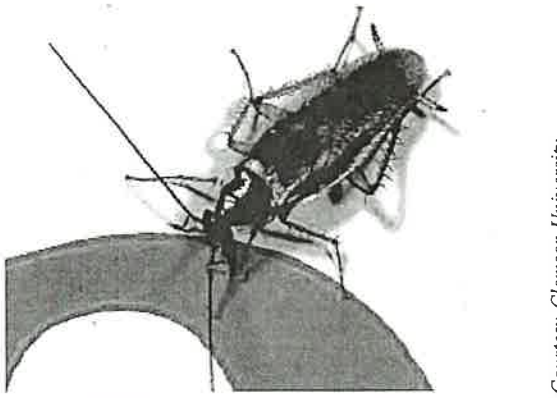


Figure 4-16. Brown-banded cockroach.

is present is essential in knowing where to focus your control efforts. The following descriptions will help you identify common cockroach species.

The German cockroach (*Blattella germanica*) is by far the most common and important cockroach species from the standpoint of public health. Adults are light brown and about 1/2 inch long, with two dark stripes running lengthwise along the pronotum or shield-like area behind the head (Figure 4-13). The nymphs are smaller and darker with a tan stripe down the middle of the back. German cockroaches reproduce very rapidly, which is one reason control can be difficult. A single mated female can produce an infestation of several thousand new roaches in less than a year.

German cockroaches require moisture, food and harborage, which is why they are most common in kitchens, bathrooms and eating areas. Preferred hiding places include cracks and crevices under sinks and toilets; beneath refrigerators, ice machines, dishwashers and stoves; next to trash containers; and inside cabinets and pantries. German cockroaches also congregate in clocks, microwave ovens and other electronic equipment. When populations are large or food is scarce, they can be found in bedrooms, closets and other nonfood areas. German cockroaches spend most of their time hidden in cracks and crevices, but can be quite mobile. They often travel between rooms or adjoining apartments along utility pipes and wires, and within wall voids.

The American cockroach (*Periplaneta americana*) is the largest cockroach found in Tennessee, measuring about 1 1/2 inches long when fully grown. It is reddish brown to brown, with a pale yellow band around the edge of the shield behind the head. Adults (Figure 4-14) have well-developed wings, but seldom fly. Nymphs are smaller and lack wings, but are otherwise similar to the adults. The developmental rate of the American cockroach is much slower than the German cockroach, usually requiring more than a year from egg to adult.

American cockroaches prefer warm, dark and moist areas. They are often found nesting in floor drains, sump pumps, pipe chases and laundry areas in basements and crawl spaces. They also frequent boiler rooms, steam heat tunnels and sewers. During warmer months, this cockroach may be found outdoors and around outbuildings and woodpiles.

The Oriental cockroach (*Blatta orientalis*) is shiny black or dark brown, and the adult (Figure 4-15) is about 1 inch long. Females have very short wings; males have wings that cover about half the abdomen. The entire life cycle may require one to two years.

The Oriental cockroach is one of the filthiest cockroach species because it commonly infests cool, dark, damp places (e.g., sewers and basements), feeding on garbage, human waste and decaying organic matter. The nymphs and adults are comparatively slow-moving and are generally found at

Figure 4-17. A thorough inspection is essential to locate cockroach harborages.

ground level. They often are found living in floor drains and sump pumps. During warmer months, oriental cockroaches also live outdoors beneath leaves and plant mulch.

The brown-banded cockroach (*Supella longipalpa*) is far less common than the German cockroach, but can be a problem in homes. Correct identification is important because it has markedly different hiding places and habits from the German cockroach. The brown-banded cockroach is similar in size to the German cockroach, but lacks the dark lengthwise stripes on the region behind the head (Figure 4-16). Instead, there are two transverse yellow bands across the base of the wings.

The brown-banded cockroach prefers to feed on starchy materials and may be found anywhere in a building. It does not require the close association with moisture, characteristic of the German cockroach, and is more often found in homes and apartments than in restaurants and other commercial food-handling establishments. In homes, brown-banded cockroaches are commonly found in rooms other than the kitchen and bathroom. Preferred locations include upper areas of ceilings, walls, cabinets and closets; behind picture frames and wall decorations; and beneath or inside furniture. This roach attaches its pea-sized egg capsules to hidden surfaces, such as the undersides of dressers and tables.

Cockroach Management

Since cockroaches may be hiding in a great many places, a thorough inspection (Figure 4-17) is essential to locate as many of these areas as possible. In performing the inspection, consider the unique habits and preferred harborage sites of the cockroach species involved. A bright flashlight, inspection mirror (for inspecting underneath, above and behind construction elements), and a set of screwdrivers, pliers, etc., to access equipment and other potential hiding places, are essential tools for conducting a professional cockroach

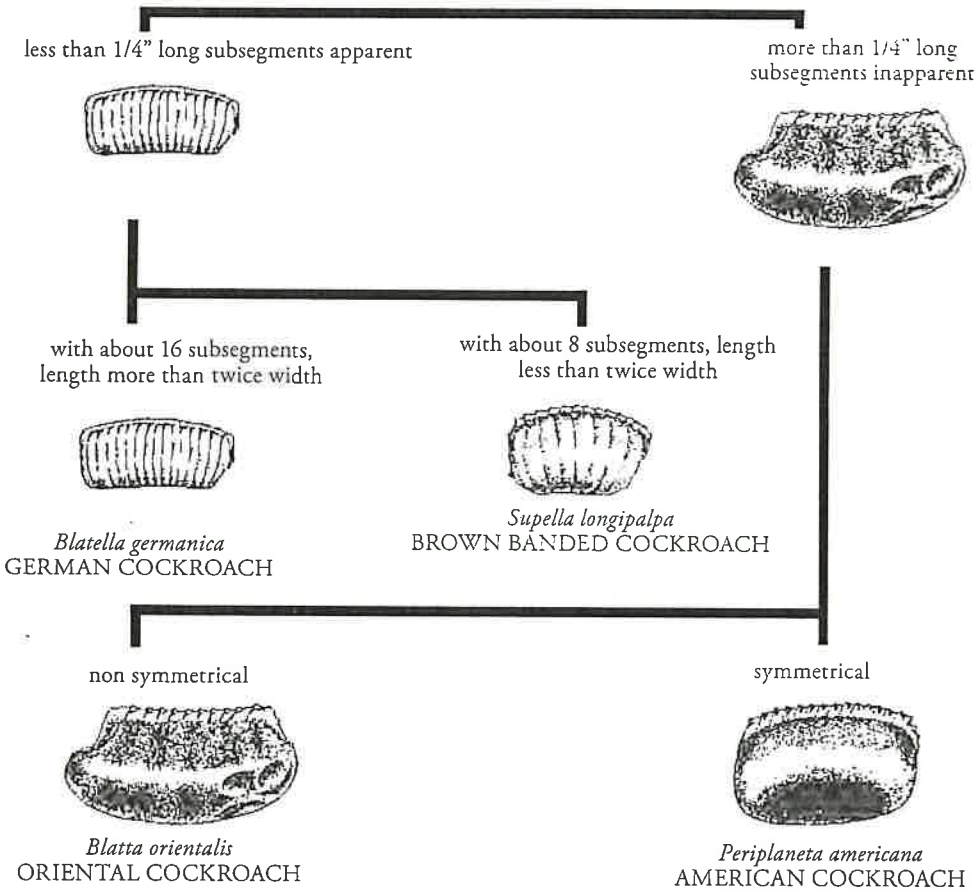


Figure 4-18. Pictorial key to egg cases of common domestic cockroaches. (Harold George Scott, Ph.D., and Margery R. Brown.)

Figure 4-19. Using a vacuum with a HEPA filter and crevice attachment is helpful to remove cockroaches when they are very abundant.

Figure 4-20. Pipe penetrations into the wall need to be sealed to prevent cockroach movement into the area.

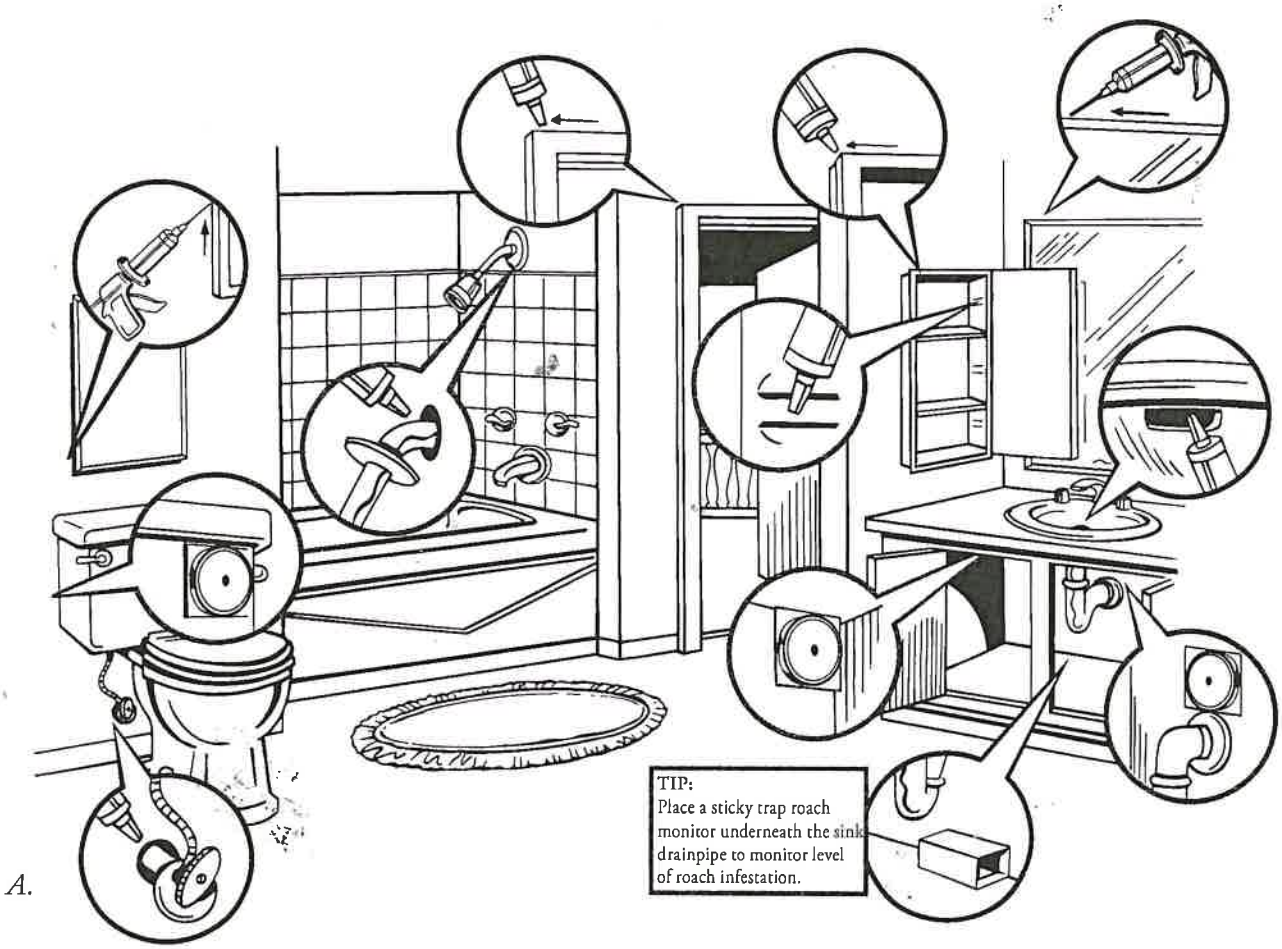
inspection. Look for live and dead cockroaches, cast spines, egg capsules and droppings, all of which aid in identification (Figure 4-18). The use of a flushing agent, i.e., an insecticide containing natural pyrethrin, can also help to reveal hidden pockets of cockroaches. Pyrethrum is highly irritating to cockroaches and forces them out into the open. Sticky traps and glue boards are useful tools for pinpointing areas where cockroaches may be hiding. Monitoring traps should be placed at strategic locations, such as beneath sinks or behind refrigerators, and positioned flush against walls, corners or at the junction of two or more construction elements. When foraging for food, cockroaches prefer to travel along edges and corners where two surfaces meet, rather than in the open.

Inspection and monitoring Cockroach inspections must be performed in an organized, methodical manner. Otherwise, areas harboring cockroaches may be missed. This is especially true when inspecting restaurants and other commercial food handling establishments where there are countless cracks and crevices in which roaches can hide. A systematic way to inspect these facilities is to begin at a door or corner and inspect one 3- to 5-foot "zone" (extending from floor to ceiling) at a time. Continue in this manner around the entire perimeter of each room (kitchen, dining area, etc.), inspecting sinks, ovens, dishwashers, cabinets and any wall-mounted fixtures or equipment. You will also need to make periodic "sidetrips" toward inner portions of rooms, i.e., away from wall areas, to inspect equipment, tables, etc. Sticky traps and glue boards are an essential component to a cockroach management program. They help pinpoint populations when the inspector is not present. Monitoring stations are also an excellent marketing device to indicate before- and after- treatment populations.

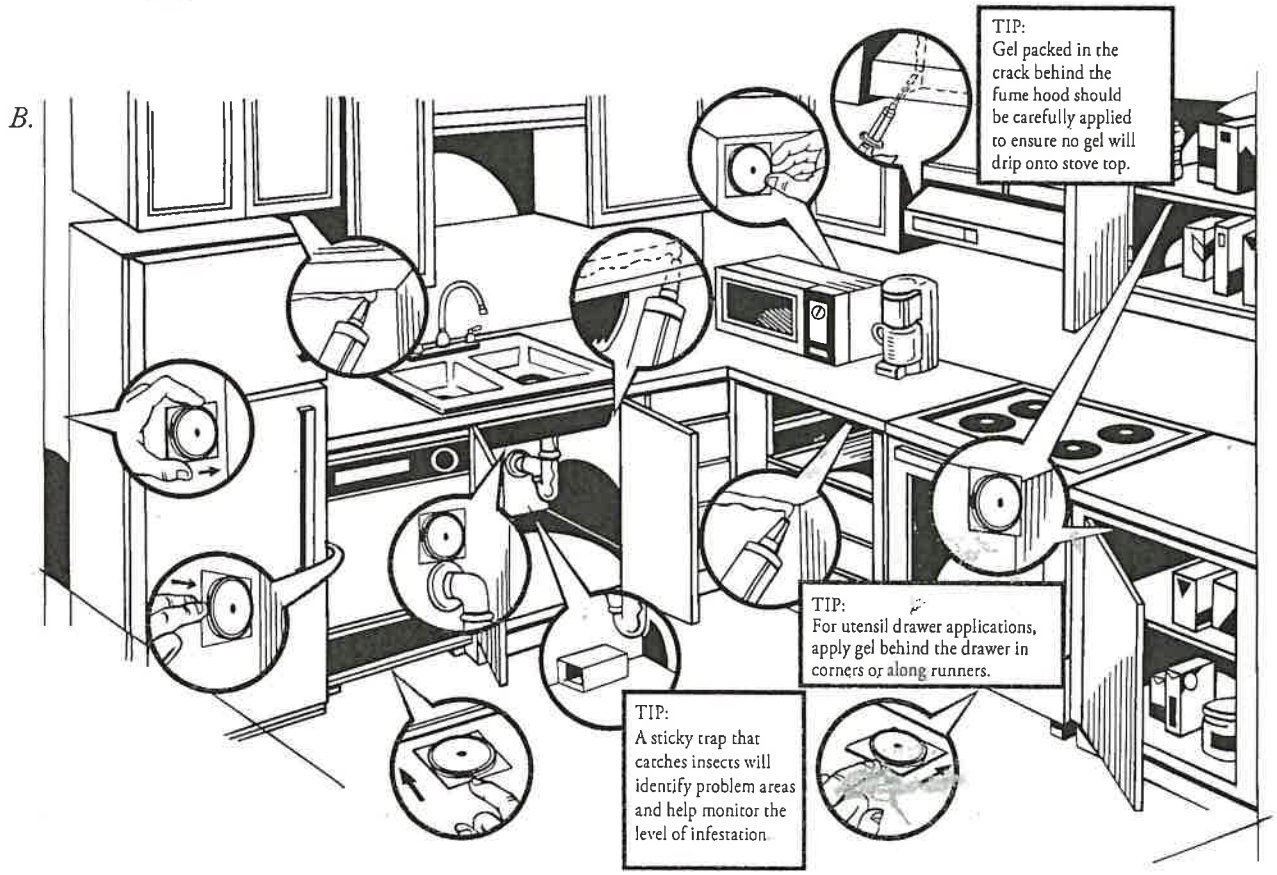
Sanitation Cockroaches are best controlled using a combination of techniques. Since roaches flourish where food, moisture and shelter are readily available, sanitation is an important step in preventing problems. Vacuum (Figure 4-19) all cracks and crevices to remove debris and food. When cockroaches are very abundant, vacuuming is the first step to remove large numbers of cockroaches. Crumbs, spills, grease and other food debris should be cleaned, and unwashed dishes, kitchen utensils and pet food should not be allowed to sit overnight. Loose food should be stored in tight-fitting containers, and garbage, cardboard boxes and paper bags should not be allowed to accumulate. Items in food storage areas should be removed from cardboard boxes, placed in pest-proof containers and stored off the floor on stainless steel racks. Moisture leaks should be repaired and floor drains routinely sanitized.

Exclusion Another element of cockroach management is exclusion, also known as pest-proofing. This involves the use of sealants such as caulk, foam, copper mesh or cement. Sealing cracks, crevices and other openings likely to harbor cockroaches eliminates the need to repeatedly treat these areas with insecticides. It is also a good idea to caulk or plug any openings where plumbing pipes or wires pass through walls or floors (Figure 4-20). This is especially useful in apartments to reduce migration of cockroaches between adjoining units. If roaches are migrating into a building from outdoors, seal cracks and other openings to the outside.

Chemical control Although good sanitation and exclusion are important, insecticides are usually required to eliminate an existing cockroach problem. To perform the treatment safely and effectively, care must be given to the type of insecticides used and how they are applied. Cockroaches spend very little time out in the open. Consequently, emphasis should be on finding and treating cockroach harborages, rather than treating along baseboards, wallcoverings and other exposed surfaces. Besides being more effective, directed placement of insecticides into cracks, wall voids and other hidden locations ensures that residues will not contaminate food or food preparation surfaces, or be contacted by children or pets.


TIP:
Place a sticky trap roach monitor underneath the sink drainpipe to monitor level of roach infestation.

A.


TIP:
Gel packed in the crack behind the fume hood should be carefully applied to ensure no gel will drip onto stove top.
TIP:
For utensil drawer applications, apply gel behind the drawer in corners or along runners.
TIP:
A sticky trap that catches insects will identify problem areas and help monitor the level of infestation.

B.

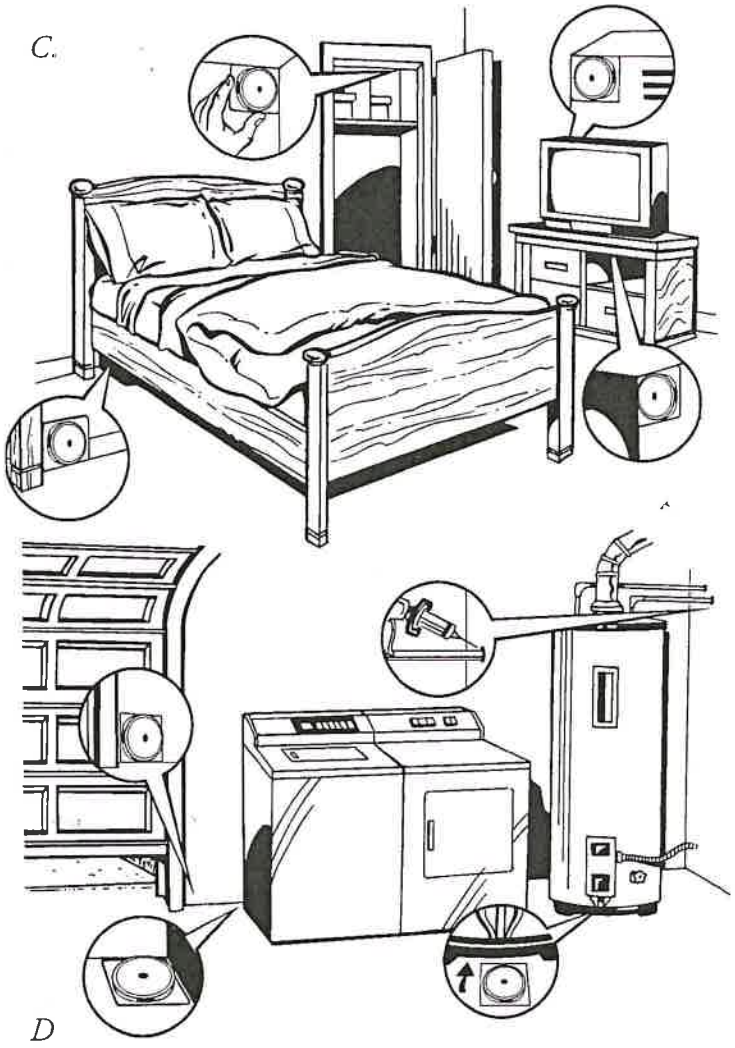


Figure 4-21. Bait station and gel placement for cockroach control in a bathroom (A); kitchen (B); bedroom (C); and garage/utility room (D). In addition to regular bait placement, place baits where the grey balloons indicate when infestations are heavy. (Drawing courtesy of Clorox Co.)

Baits are the most widely used formulation for managing cockroaches. Cockroach baits contain a slow-acting insecticide incorporated into a food attractant. Roaches locate and feed on the bait and crawl away to die, usually within a few days. Bait carried back to the nesting area also kills other roaches after being expelled in the sputum and feces. Some baits come prepackaged with the insecticide and food attractant confined within a plastic, child-resistant container; others are formulated as pastes, dusts, granules or gels. Gel baits are the tool of choice for cockroach control. Since baits must be ingested to be effective, they must be placed within a few feet of where cockroaches are likely to be living (Figure 4-21). Rotate baits throughout the year to avoid bait aversion problems.

A wide variety of insecticide active ingredients and formulations is available for cockroach control. Residual insecticides are commonly used and provide effective residues lasting from a few days to several months. For these products to be effective, cockroaches need not be present at the time of application. The roaches are killed if they consume a bait or remain on a treated surface long enough to absorb a lethal dose of insecticide. Residual insecticides known as insect growth regulators (hydroprene, pyriproxyfen, methoprene) are also used in cockroach control. These materials disrupt the cockroaches' normal growth and development, causing the population to decline.

Residual insecticides may be formulated and applied as liquid or aerosol sprays, dusts, granules or baits. Liquids and aerosols are typically used for injection into cracks and crevices, whereas dust formulations are used primarily for treating wall voids and hollow spaces beneath cabinets and appliances.

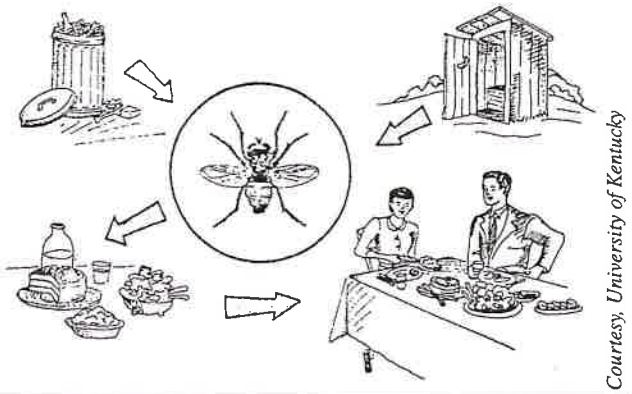
Non-residual insecticides are those products applied to obtain control of cockroaches only during the time of treatment. Pyrethrin or resmethrin are often used in conjunction with residual products to locate and "flush out" hidden infestations of cockroaches. They can also provide rapid (although short-lived) knockdown of cockroaches present at the time of application. Non-residual insecticides are usually applied with aerosol or ultra low volume (ULV) equipment, and directed into areas suspected of harboring cockroaches. Indiscriminate dispersal of non-residual insecticides into the air (i.e., fogging or space treatment) in kitchens, dining rooms, storage areas, etc., should normally be avoided because it will only disperse and drive cockroaches deeper into wall voids and other protected locations.

Because cockroaches are typically found in areas where food is prepared, served or stored, special care must be taken not to contaminate food, dishes, cooking utensils or food preparation surfaces with insecticides. Use only materials that are labeled for use in food-preparation areas. Before treatment, these items may need to be removed, placed in plastic bags or covered with polyethylene sheeting.

Before treatment, it is essential that all insecticide labels be read in their entirety. Some products can only be used in "nonfood" areas such as garbage rooms and mop closets, where foods are never processed, prepared, served or stored. Other insecticides can only be applied into cracks and crevices to limit potential contact with food or food preparation surfaces. As with any insecticide application, the label is the best guide.

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

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



Courtesy, University of Kentucky

Figure 4-22. Flies have a high potential for spreading disease organisms because they show little preference when selecting feeding sites.

Flies

Flies, especially in large numbers, can be very annoying and seriously interfere with work and recreational activities. For centuries, flies have had a significant impact on human health and welfare because of their ability to spread disease organisms. Most fly species have evolved to feed and breed in decaying organic matter, including garbage, sewage, dead animals or manure. Flies have a high potential for spreading disease organisms because they show little preference when selecting feeding sites. They will just as readily feed on dog droppings in the lawn as they will potato salad at a family picnic (Figure 4-22).

Flies are well equipped to transmit bacteria and other disease-producing organisms. Most are highly mobile, and their bodies are covered with thousands of tiny hairs. Flies have pads on the bottom of their feet, which aid in the mechanical pickup and transfer of pathogenic organisms. Many species, such as the house fly, also have "sponging" mouthparts for lapping up and ingesting liquid foods. As the house fly feeds, it regurgitates digestive enzymes and bacteria onto the food surface.

Other species of flies, including black flies, deer flies, horse flies and stable flies, have piercing/sucking mouthparts designed to suck blood. Bites of these flies are painful and may seriously interfere with outdoor activities.

All flies have four stages in their development: egg, larva, pupa and adult. The habitat in which the adult female chooses to lay her eggs differs depending upon species (Table 4-1). Many flies of public health significance lay their eggs in moist, decaying organic matter — human garbage and waste; manure of domestic animals; or decaying vegetation, fruits or vegetables. After the eggs hatch, the larvae (called maggots) feed upon organic material, eventually transforming into the pupal stage from which they later emerge as adults. The development rate varies among species and is greatly influenced by temperature. Under ideal conditions, development can be completed in as little as one week. Considering that a single adult fly can lay several hundred eggs, the potential for a serious fly infestation is enormous. Some flies disperse many miles from their original breeding site. More often, the breeding area is nearby, such as a pile of manure-soaked straw, a rotting potato beneath a cabinet, or a poorly maintained dumpster behind a restaurant.

Fly Management

An essential first step in managing fly problems is correctly identifying the species involved. This may require the assistance of an entomologist. Some of the more common domestic flies are shown in the taxonomic key below. Proper identification is important because this will help to identify possible breeding sites for corrective action. It may also identify conditions contributing to the infestation, such as poor sanitation or inadequate screening of doors or windows.

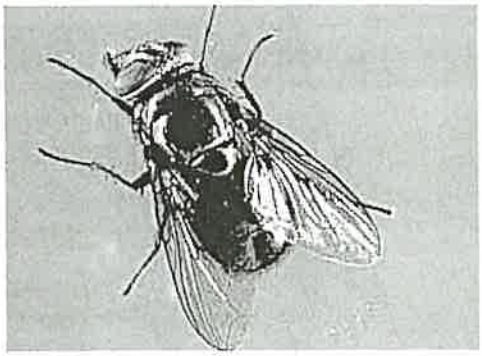
Non-chemical control Sanitation is the single most important step in controlling flies. In general, the poorer the sanitation, the greater the fly problem. However, even small amounts of garbage or waste can support hundreds of developing flies. Fermenting organic matter under food preparation equipment, or a neglected floor mop, can support a serious infestation of fruit flies. The same is true for a seldom- cleaned floor drain which may be the source of moth flies or phorid flies. Efforts must be made to find and eliminate the breeding source; otherwise, the problem is likely to continue regardless of what other control methods are attempted.

Clean garbage cans and dumpsters regularly and keep them covered to prevent attracting flies. Trash should be collected at least twice a week from residences, and daily from business establishments. Promptly removing waste ensures that if flies do begin breeding in garbage, they will be removed before a new generation reaches the adult stage. Garbage should be buried in a sanitary landfill. Incinerators may be practical for large cities where landfills are too remote. Sanitary disposal of sewage and industrial waste is essential in any municipal fly-control program.

Open sewage pits and wastes from canneries, feed mills, poultry and meat packing houses are sources of heavy fly breeding and can cause more problems in nearby residential areas. Adequate disposal methods should be available at the plant, or holding facilities should be available from which wastes can periodically be transported to a sanitary landfill. Public health agencies must secure the support of other agencies that will be involved with waste disposal.

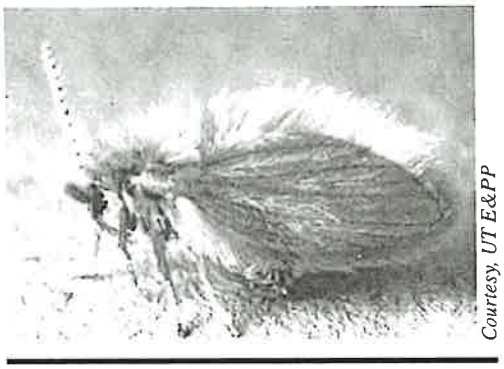
Another very important method of preventing fly problems in buildings is exclusion. Exterior doors and windows should be properly screened and kept closed whenever practical. Plastic strip curtains and air doors can be used to deny fly access in some situations.

Once flies are inside a building, light traps can be used to capture the winged adults. These traps usually employ ultraviolet (UV) light as an attractant, and kill either by electrocution or entrapment on replaceable, glue-covered cardboard inserts. If these traps are to be effective, they must be properly positioned along routes of fly entry and movement. They must also be installed at the proper height (ideally within 5 feet of the floor) and away from windows and other competing light sources. The "glow" of a light trap should not be visible from outside; otherwise, the trap will attract insects into the building when doorways are open. Bulbs should be replaced each year, and catch pans or glue boards



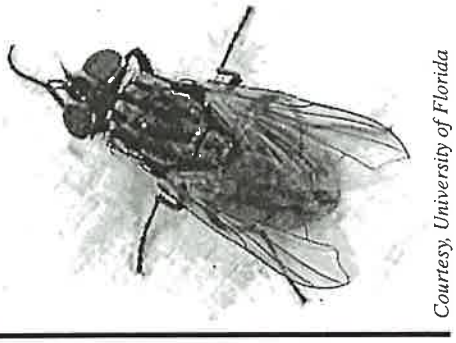
Courtesy, University of Florida

Figure 3-1. Blow fly.



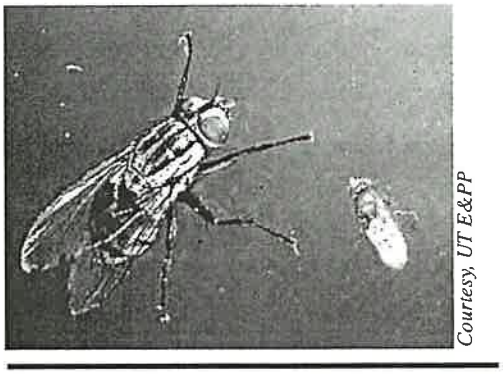
Courtesy, UT E&PP

Figure 3-1. Moth or Drain fly.



Courtesy, University of Florida

Figure 3-1. House fly.



Courtesy, UT E&PP

Figure 3-1. Comparison of flesh fly and fruit fly.

Insect	Identifying Characteristics	Preferred Host Material	Adult Occurrence	Life Cycle	Management Chemical	Management Other
House Fly	1/4 inch long; dull gray with 4 stripes on thorax; 4" wing vein sharply angled	Animal waste, garbage and other decaying organic matter	Most abundant later Summer and early full	7 to 45 days	Residual and contact sprays; baits, traps, larvicides	Sanitation, exclusion, habitat destruction
Flesh Flies,	2 to 3 tines larger than house fly; gray and black checkerboard pattern on the abdomen	Garbage, manure and animal carcasses	Common in warm months	2 to 4 weeks	Residual and contact sprays; larvicides	Sanitation and habitat destruction
Blow Flies	About twice as large as house fly; metallic blue or green in color	Garbage, manure and animal carcasses	Spring and summer	2 to 4 weeks	Residual and contact sprays, larvicides	Sanitation and habitat destruction
Fruit Flies	1/8 inch long; yellowish brown; hovers around ripe or decaying fruits	Decaying fruits and vegetables; garbage	Most abundant later summer arid early full	1 to 2 weeks	Residual and contact sprays	Sanitation and habitat destruction
Phorid Flies	Superficially resemble fruit flies, but are more humpbacked	Decaying vegetables and animal matter	Most abundant in warmer months	1 to 2 weeks	Residual and contact sprays	Sanitation, habitat destruction and moisture control
Moth Flies	1/8 inch long; body and 'kings densely covered with longhairs	Decaying Organic matter, especially around drain and sewers	Mere common in warmer month,	2 to 3 weeks	Residual and contact sprays	Sanitation, habitat destruction and moisture control
Cluster Flies	Superficially resemble house flies, but are slightly larger and more sluggish in movement	Parasite on earthworms	Abundant in spring and fall	4 to 6 weeks	Residual and contact sprays	Screening and caulking around eaves and windows, etc,

Table 4-1. Summary of important domestic flies (Modified from Wilson et al. 1977).

serviced routinely to prevent dead insects from becoming a food source for other insects (e.g., dermestids).

Cluster flies, face flies and blue bottle flies may overwinter in homes. Exclude flies before they enter homes by sealing possible entry points. Once overwintering flies are found indoors, they can be removed with a vacuum or light trap. Sometimes, a light trap in a false ceiling will be effective. If flies are overwintering in wall voids, it may be necessary to inject an insecticidal dust into this space.

Bottle or jar traps are also useful for capturing adult flies. Bottle traps are especially useful for trapping fruit flies and phorid (humpback) flies, once the breeding source is eliminated. (Potential breeding sites for these tiny flies include rotting fruits or vegetables, spillage in trash cans or recycling bins, unsanitized floor drains and food-soiled mops or cleaning rags). A simple jar trap for fruit or phorid flies can be made by placing a paper funnel into a jar, which is then baited with a few ounces of cider vinegar as an attractant.

Chemical control In most cases, insecticides should be considered a secondary form of fly control after sanitation, exclusion and trapping. Regardless of how effective a treatment may appear, unless you locate and eliminate the breeding source and/or point of entry into a structure, the problem will continue. Moreover, because flies reproduce rapidly, they quickly develop resistance to most insecticides. Various types of insecticide treatments are used in fly control such as the following.

Non-Residual (Contact) Sprays — Temporary control of adult flies can be achieved by applying synergized pyrethrins or short-residual synthetic pyrethroids such as allethrin, sumethrin or esmethrin. While these insecticides quickly knock down adult flies, they provide no lasting effect and do not control developing larvae. Application can be made with aerosol-type dispensers, ultra low volume (ULV) or fog-generating equipment. For optimum results indoors, apply the precise amount of material per cubic area specified on the label. When performing space treatments, the applicator should wear goggles and a respirator. He or she should also ensure that no people are present, and that any food, utensils or food preparation surfaces are covered or washed before reusing.

Residual Sprays — Residual insecticides are sometimes useful in fly control, but only as a supplement to other methods already mentioned. Treatments should be applied as coarse, low- pressure sprays, confined to surfaces where flies rest and are likely to absorb a lethal dose (e.g., areas around dumpsters or sun-exposed exterior walls adjacent to a doorway). Several different insecticides are registered. Synthetic pyrethroids (e.g., cypermethrin, cyfluthrin) are also very effective, especially wettable powder or microencapsulated formulations.

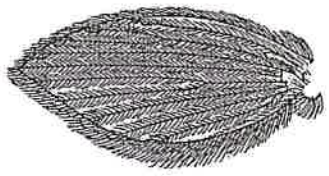
Fly Baits — Baits are a mixture of toxicant and attractant and are used primarily to control house flies. Most baits contain sugar and the house fly sex pheromone, muscalure. These keep the fly in contact with the toxicant for a longer time. Fly baits are typically formulated as granules, which are placed in shallow trays or scattered around dumpsters and other fly breeding areas. Their effect is short-lived unless the bait is reapplied.

Brief Taxonomic Key for Commonly Encountered Flies

1. Small fly — less than ¼ inch in length 2
1'. Large fly — about ¼ inch in length or larger 8

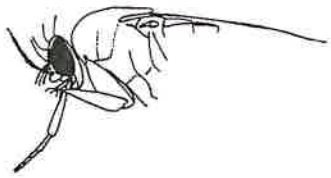
2. Tan or brown in color 3
2'. Dark color 5

3. Wing has unique vein pattern (shown below) — body and wings covered with tiny hairs so that it resembles a moth ..... ***Moth Fly***



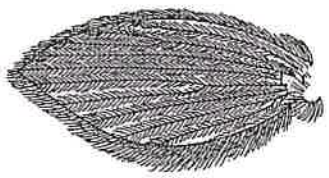
3'. Pattern in wing veins not as described above 4

4. Has red eyes — thorax does not have humpbacked shape ..... ***Fruit Fly***
4'. Thorax has humpbacked shape (shown below) — head is small in comparison to body — does not have red eyes ..... ***Phorid Fly***



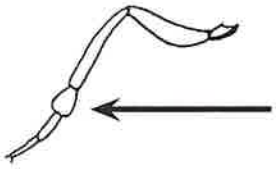
5. Black, shiny color with bronze tints on thorax — body has long, thin shape — has reddish brown eyes — iridescent wings fold flat over abdomen — has sponging, lapping mouth-parts ..... ***Cheese Skipper***
5'. Not as described above 6

6. Wing has unique vein pattern (shown below) — body and wings covered with tiny hairs so that it resembles a moth ..... ***Moth Fly***

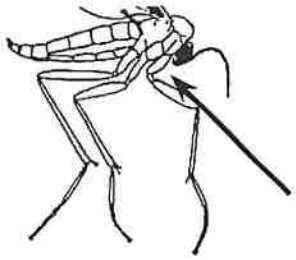


6'. Not as described above 7

7. The first segment of the tarsi on the hind leg is enlarged (as shown below) ..... ***Sphaerocerid Fly***



7'. Small, often tiny dark fly — has thin abdomen, legs and wings — the first leg segment, the coxa, is long and thin (as shown) ..... ***Fungus Gnat***



8. Medium-sized fly — body has shiny, metallic, green or blue color ..... ***Blow Fly or Bottle Fly***

8'. Not metallic colored, size varies 9

9. Top of thorax has dark, longitudinal stripes 10

9'. No dark stripes on top of thorax..... 12

10. Three dark stripes on top of thorax — top of abdomen has checkerboard pattern of dark and light gray squares — medium to large flies ..... ***Flesh Fly***

10'. Four dark stripes on top of thorax, ¼ to ⅜ inch in length 11

Flesh Fly

House/Face Fly

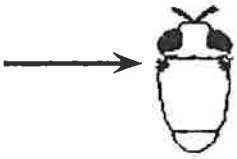
11. Calypteres have no tuft of bristles (shown below)..... House Fly

11'. Calypteres with a tuft of bristles (shown below) ..... ***Face Fly***

Face Fly

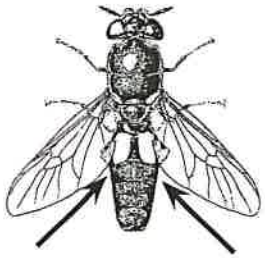
House Fly

12. Medium-sized, dark colored fly — wings fold over flat over body — has patch of yellow hairs present on upper (see below), front sides of the thorax ..... ***Cluster Fly***



12'. Large flies, ½ inch to more than 1 inch in length — color varies 13

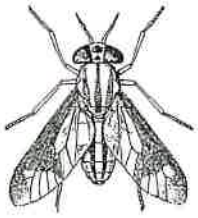
13. Long, thin, black fly about 1 inch in length — has two light-colored patches on top of abdomen just behind thorax (see below)..... ***Soldier Fly***



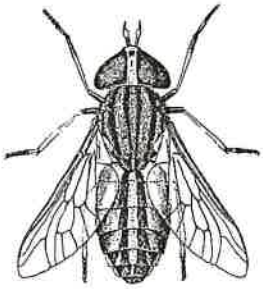
13'. Not as described above 14

14. Fly is about ⅜ to ½ inch in length — tan or brown color — visible biting mouthparts — has dark stripe or marking on wings ..... ***Deer Fly***

14'. Larger, more robust flies with varying colors — large eyes, sometimes brightly colored — size may vary from 5/8 inch to over 1 inch in length — visible, strong biting mouthparts..... ***Horse Flies***



Deer Fly



Horse Fly

(Taxonomic key courtesy of the University of Kentucky)

Review Questions

1. The most common and important pest cockroach is the _____.
   A. Asian
   B. American
   C. German
   D. Australian

2. American cockroaches like an environment that is _____.
   A. very hot and moist
   B. warm and moist
   C. hot and dry
   D. lukewarm and average humidity

3. Female Oriental cockroaches have _____.
   A. light markings on their wings
   B. two bands across their thorax
   C. short wings
   D. light markings on their thorax

4. Cockroaches need _____to be successful.
   A. food, moisture, harborage
   B. food, moisture, open spaces
   C. warmth, food, open spaces
   D. cracks, crevices, food

5. Oriental cockroaches prefer a _____ environment.
   A. damp and cool
   B. warm and moist
   C. high and short
   D. small and wet

6. The _____ cockroach does not require a close association with moisture.
   A. Brown-banded
   B. American
   C. German
   D. Oriental

7. _____are the most widely used formulation for cockroach control.
   A. Emulsifiable concentrates
   B. Dusts
   C. Wettable powders
   D. Baits

8. German cockroaches have _____.
   A. two bands across their head.
   B. two stripes on their thorax
   C. light markings on their wings
   D. short wings

9. To treat for carpenter ants, the certified technician must work under the direction of an operator licensed in _____.
   A. general pest and rodent control (GRC)
   B. horticulture, lawn, and turf (HLT)
   C. wood-destroying organisms (WDO)
   D. public health control (PHC)

10. _____ is the best way to get an insecticide to an entire Pharaoh ant colony.
   A. Spraying
   B. Dusting
   C. Baiting
   D. Fogging

11. *Acanthomyops* or yellow ants smell of _____ when crushed.
   A. chocolate
   B. blue cheese
   C. lemon
   D. rotten coconut

12. Odorous house ants smell of _____ when crushed.
   A. chocolate
   B. blue cheese
   C. lemon
   D. rotten coconut

13. _____ants may move their colony as often as every 23 days.
   A. Carpenter
   B. Odorous house
   C. Fire
   D. Pharaoh

14. When baiting for ants indoors, applying persistent contact insecticides does not affect baiting success.
   A. True
   B. False

15. Ants are not as sensitive to odors as cockroaches, so using hands that have touched cigarettes to place baits will not deter ants.
   A. True
   B. False

16. Chemical control will eliminate a fly problem.
   A. True
   B. False

17. _____ often overwinter in homes in Tennessee.
   A. Dragonflies, moth flies and cluster flies
   B. Cluster flies, face flies and blue bottle flies
   C. Fruit flies, dragonflies, and house flies
   D. Cluster flies, fruit flies, and warble flies

18. _____is the single most important step in controlling flies.

A. Spraying resting areas
B. Spraying breeding areas
C. Using light traps
D. Sanitation

19. The glow of light traps should not be visible from outside a structure because _____.

A. it will attract insects into the structure
B. will cause people to congregate.
C. less insects will enter the structure.
D. None of the above

20. Most fly baits contain_____.

A. salt and pepper
B. sugar and salt
C. salt and sex pheromone
D. sugar and sex pheromone

21. Blow fly larvae feed in/on _____.

A. areas with good air circulation
B. dead animals
C. earthworms
D. none of the above

22. Cluster fly larvae feed in/on _____.

A. areas with good air circulation
B. dead animals
C. earthworms
D. none of the above

Answers: 1. C, 2. B, 3. C, 4. A, 5. A, 6. A, 7. D, 8. B, 9. C, 10. C, 11. C, 12. D, 13. B, 14. B, 15. B, 16. B, 17. B, 18. D, 19. A, 20. D, 21. B, 22. C.

Chapter 5

Parasitic, Biting and Stinging Arthropods

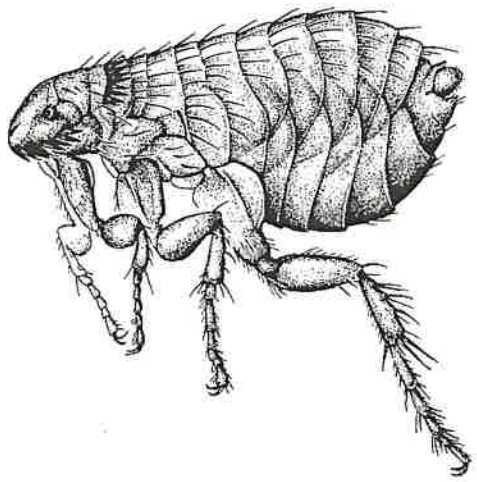
Arthropods that bite or sting to defend themselves or those that feed on the blood of people or domestic animals are serious, and sometimes dangerous, pests. Bites or stings may result in localized painful itching and swelling, which, if scratched, may even lead to a bacterial infection. Some arthropods transmit disease-causing organisms through the wounds they cause. Some stinging and blood-feeding pests inject venoms capable of causing allergic reactions, which can be fatal. Arthropods that feed on the blood of people and their pets include mosquitoes, some true bugs, fleas, lice, ticks, midges and some mites. Biting or stinging arthropods include bees, wasps, spiders and scorpions in addition to ants, which were previously discussed.

This chapter describes those parasitic, biting and stinging pests that are most commonly found in or around homes or other buildings. The ones that may require pest control include bugs, fleas, bees, wasps, mites, ticks and spiders. Medical or health professionals usually supervise the control of lice.

Mosquitoes and their control are not included in this manual. To control mosquitoes on public lands and public waters, a certified pest control professional must be under the direction of someone licensed in Public Health Control (PHC).

Fleas

The cat flea, *Ctenocephalides felis* (Figure 5-1), is the most common flea found on cats and dogs in Tennessee. These fleas are about 1/16 inch long and are reddish-brown in color. The body is flattened from the sides with backward projecting spines so they can easily walk through animal hair. Parts of the legs are enlarged for jumping, which allows an adult flea to jump almost 200 times its height.



Courtesy, University of Kentucky

Figure 5-1. The cat flea is the most common flea found on cats and dogs in Tennessee.

Most of us are well aware of the flea and the itch produced by its bite. Not only are flea bites irritating, but fleas can also transmit several disease-causing organisms to humans. The organisms that cause plague and flea-borne typhus are transmitted to humans by fleas that have fed on infected rodents, such as rats. Fortunately, these two diseases are seldom encountered in Tennessee. Cat fleas, however, are a veterinary concern because they are able to transmit dog tapeworm, *Dipylidium caninum*. The flea larvae ingest the tapeworm eggs that were dropped from the dog's anus by the adult tapeworm. Cats and dogs can be infected if they groom and consume an adult flea infected with tapeworms. Humans can also be infected if they accidentally consume an infected adult flea.

Other, less common species of fleas that you may encounter are the dog flea, mouse flea and rat flea. If no pets have been present and the structure has had an infestation of rodents, squirrels or other wild hosts, you should suspect one of these other flea species. When their host is gone, either because of death or removal, the adult fleas will seek a new host. Apply a labeled insecticide to areas where these hosts were last present to kill any stray fleas.

Fleas are obligate ectoparasites, meaning they must stay on or close to a host to survive. Fleas will not stray far from host resting areas. Cat flea hosts include cats, dogs, opossums, foxes, occasionally rats and other urban animals. Although adult fleas prefer to feed on dogs, cats or other small animals, they will attack humans when pets are not available. Cat fleas do not develop very well on human blood and a population will soon die out if no preferred hosts are present.

Life Cycle

Like butterflies, fleas have an egg, larval, pupal and adult stage (Figure 5-2). Flea eggs, which are white, oval and 1/50 inch long, are laid on the pet, but soon roll off because the eggs lack any spines that would hold them to the pet's hair. This explains why most fleas are found where the pet rests.

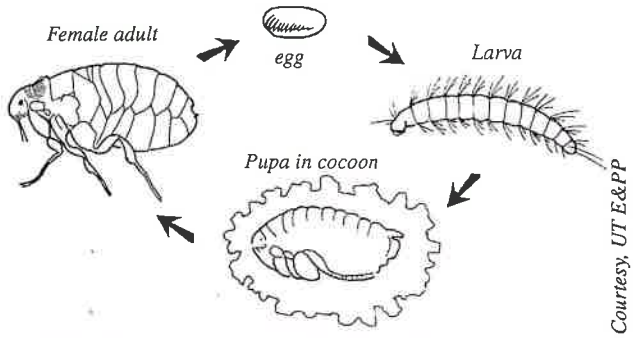


Figure 5-2. Cat flea life cycle.

Adult flea feces, which contain partially digested blood, also drop off the pet. This partially digested fecal blood is seen as dark specks when a flea-infested cat is combed. After hatching from eggs, flea larvae feed on the partially digested blood and other organic matter found in a house or yard. Larvae are usually hidden deep in carpet fibers, under furniture cushions and in other protected spots.

The small, white, wormlike larvae complete development and spin a pupal cocoon. Materials such as carpet fibers or grains of soil, which are present in the larval environment, are incorporated into the cocoon. This camouflages the pupa and protects it from predators. Larvae are the most susceptible stage to drying. The cocoon is highly resistant to drying out and insecticide penetration. Development continues inside the cocoon, where the preemergent adult waits for a stimulus that causes it to emerge. Such stimuli can include pressure, vibration or heat, indicating the presence of a host. Preemergent adults can persist in the cocoon for up to 20 weeks. Estimates of development time from egg to adult are given in Table 5-1.

The male and the female feed and mate on the host. The sucking mouthparts of an adult are formed by three stylets that probe the skin for a small blood vessel. The tip of the tube enters the blood vessel cavity, while the other two stylets intermittently inject saliva. Adults live from four to 25 or more days, during which time a female may lay between 158-420 or more eggs.

Management of fleas

Non-chemical control Vacuuming areas frequented by pets will provide many benefits to those stricken with fleas. Vacuuming these areas can remove about 60 percent of the flea eggs and 27 percent of the larvae. The wormlike larvae wrap around carpet fibers to prevent being removed by the vacuum. Vacuuming also removes organic matter and fecal blood the larvae need for food to mature. Stimulus provided by the vacuum causes the adults to emerge from their cocoons. If not collected with the vacuum, the newly emerged adults, which were protected in the cocoon, will now be exposed to insecticide applications. It is important to dispose of the vacuum cleaner bag immediately after use in an outside garbage can with a tight-fitting lid. Lastly, vacuuming will straighten the carpet fibers so that if an insecticide is applied it will penetrate to the carpet base where the larvae are found. Steam cleaning will kill most of the fleas, including those in cocoons, as well as removing larval food.

Pets can be bathed in a mild detergent or shampoo. Fleas will drown in the bath water. Any fleas that survive may die later due to the disruption of their waxy layer caused by the detergents.

Adult fleas can be removed from a pet with a flea comb. If the comb is quickly dipped in soapy water, the flea will drown. Combing cats is especially helpful because they do not tolerate baths well.

Concentrating control efforts, such as limiting a pet's access to carpeted areas and confining pets to one resting area, are other ways to reduce flea infestations indoors.

Landscaping practices can affect outdoor flea populations. Mow grass, keep weeds down and trim shrubs near animal-resting sites to expose flea eggs and larvae to sunlight, which causes them to dry out and die. Irrigating areas surrounding buildings, but not directly against a building, may kill fleas by drowning.

Chemical control Insecticides used for flea control can be grouped into two types: insect growth regulators and adulticides.

Insect growth regulators (IGRs) prevent immature stages from completing development to the adult stage and prevent the female from laying "healthy" eggs. IGRs, therefore, are important because they break the life cycle of the flea. They will not, however, shorten the life span of the adult flea. IGRs are chemicals that either mimic the hormones that occur in insects or prevent the formation of chitin used in the insects' outer shell. Some IGRs can be applied to animals or to the pets' resting places.

Adulticides or contact insecticides are substances that kill the adult fleas. If immature stages are contacted by the adulticide, they may also be killed. Adulticides can be applied to pets or to their resting areas, as specified by the label. Often formulations are made that combine an adulticide and an IGR. Such a combination may be the most efficient formulation to use.

Steps for a chemical flea control program The following measures should be performed on the same day to maximize

Temperature in Fahrenheit	Development Time	Range in Development Time
89.6	17 days	12 – 22 days
80.6	24 days	16 – 50 days
69.8	40 days	26 – 140 days

Table 5-1. Time at each temperature for 50 percent of cat flea population to go from egg to adult at 75 percent relative humidity

flea control success: 1) treat the pets, 2) vacuum areas visited by pets, and 3) treat both indoors and outdoors.

1. Treat the pet — Adult fleas spend most of their life on the animal — not in the carpet. Untreated pets will continue to be bothered by fleas. They may also bring fleas in from outdoors, eventually overcoming the effectiveness of the insecticide used inside the home.

Pets can be treated either by a veterinarian or the pet owner. A variety of formulations for pets are available from veterinarians. Cats and some breeds of dogs may be sensitive to insecticides, and some insecticides are not recommended for use on kittens and puppies. Always carefully check the insecticide label before using any product to ensure the product is recommended for safe use on a pet. It is also a good idea to check with a veterinarian before deciding on a pet treatment.

IGR products containing lufenuron, methoprene or pyriproxyfen can be used to treat pets. Products containing the adulticides, such as imidacloprid or fipronil, are also available from veterinarians to kill adult fleas on pets. These are usually applied as a spot-on to the pet between the shoulder blades. Most pet owners are satisfied with the control provided by these two products.

Flea collars containing adulticides can also be used. Insecticides are impregnated into the collar and are spread throughout the pet's hair by grooming. Check label for prescribed treatment time. Prolonged use of flea collars can cause dermatitis under the collar, so check this area for rashes. Discontinue use of a flea collar if a rash occurs.

Adulticides are also available in other sprays, collars, dips, dusts, flea powders, foams, mousses, shampoos and spot-ons. Check label precautions or consult a veterinarian before using a product on a pet!

2. Vacuum flea-infested areas of the home to —

- Remove eggs and larvae.
- Remove fecal blood and other organic matter that serves as larval food.
- Stimulate adults to emerge from insecticide-resistant cocoons.
- Straighten carpet fibers to allow pesticides to penetrate to the carpet base where larvae are found.

3. Treat indoors — Besides vacuuming, the pet owner should do the following before treating:

- Allow access to all breeding sites by removing all toys, clothing and stored items from floors, under beds and in closets.
- Cover fish tanks, and disconnect their air pumps.
- Remove pet food and water dishes.
- Pet bedding should be washed, dry cleaned or destroyed.

Only the person performing the application should be present during treatment. People and pets should not contact treated surfaces until the spray has dried. Drying may take several hours, depending on carpet type, ventilation and method of application. Opening windows and running the fan or air conditioner after treatment will enhance drying and minimize odor.

One way to determine if the sprayed areas are dry is to use the paper towel test. After the estimated drying period, reenter the house and place a clean paper towel on the treated surface, such as on the carpet. With your shoes still on, step on the paper towel. If the towel remains dry, it is safe to reenter. If the towel is wet, wait a few more hours and repeat the paper towel test. (Creig Manson [Ciba-Geigy-Sandoz] in Oi 1996).

Thoroughly treat all likely areas of flea development, such as carpets, throw rugs, under and behind beds and furniture and beneath cushions on which the pet rests. Areas where the pet spends the most time or sleeps are where most flea eggs, larvae and pupae will be concentrated. Hardwood and tile floors usually do not require an insecticide treatment, but should be thoroughly vacuumed and mopped.

In additional to sprays, boric acid products labeled for flea control can also be worked into the carpet. The larvae are killed by ingesting the boric acid as they feed. Adult fleas are not affected by boric acid because they feed on blood. Treat a small area first to determine whether the product will stain the carpet. Do not use these boric acid products outdoors.

Pet owners may see some fleas for two weeks or more following treatment. If all infested areas were treated initially, these fleas are probably newly-emerged adults that have not yet died from the insecticide. Vacuuming is recommended in this case rather than applying insecticide. If adult fleas are seen beyond two to four weeks, retreatment of the premises (and pet) may be necessary.

4. Treat outdoors — Most flea problems in Tennessee can be eliminated by treating the pet and the interior of the home. In cases where the pet spends a majority of its time outdoors, it may also be necessary to treat outdoors. One way to determine if the yard is infested is to walk around the property wearing white socks, pulled to the knee. If fleas are present, they can be seen against the white background of the socks.

Outdoor flea treatment should focus on areas where the pet rests, sleeps and runs, such as a doghouse and kennel area, under decks, along fences and next to the foundation. It is seldom necessary to treat the entire yard or open areas exposed to full sun because flea eggs and larvae will dry out and die when exposed to sunlight.

Fleas should be successfully controlled using the techniques described above. Initiate a flea control program no later than April and vacuum infested areas twice a week.

Ineffective treatments?

1) Flea traps are effective in detecting the presence of fleas and may provide some control (Oi 1996).

2) Ultrasonic devices were ineffective in managing flea populations (Hinkle et al. 1990).

3) Leaves of southern bayberry, *Myrica cerifera,* have not been found to be repellent to cat fleas (W.H. Kern and R.S. Patterson unpublished data).

4) Fresh bayberry, pennyroyal, eucalyptus, rosemary or citronella have not been documented to effectively control fleas (Oi 1996).

Ticks

Ticks are external parasites of mammals, birds and reptiles and feed only on the blood of their hosts. They can be distinguished from insects and spiders because the head, thorax and abdomen are fused into a single, sac-like body region. The nymphs and adults have four pairs of jointed legs and no antennae. Ticks are found walking on or attached to their hosts or in areas frequented by their hosts. These areas include woodlands, weedy or brushy areas, lawns, dog kennels and dog runs. Ticks frequently wait for a host on vegetation along trails and paths traveled by people or animals.

Life Cycle

All of the common ticks of Tennessee have four life stages — egg, larva, nymph and adult (Figure 5-3). Each of the stages, other than the egg, requires a separate animal host to complete its development, which, all together, may be two or three years long. Each blood-engorged female leaves her host animal and lays a single mass of 3,000 to 6,000 eggs. The eggs hatch into larvae about 1/40th of an inch long with three pairs of legs. Immediately after hatching, the larvae climb onto the nearest vegetation and wait for an animal to pass by. They grasp the hair or feathers of the passing animal and attach themselves by inserting their mouthparts into the skin. They remain attached for several days and take in blood until they are greatly distended. They drop off the host after they are full of blood and molt to the eight-legged nymph. Nymphs usually overwinter and follow the same feeding process the next year. After feeding, they drop off again and molt to adult males and females. The adults usually overwinter and emerge in the spring to find the third host. Mating occurs on this host. When she is full of blood, the female detaches and lays her eggs. Adult, engorged females can grow to more than 1/2 inch.

Kinds of Ticks

Three kinds of ticks are frequently encountered around homes or in recreation areas in Tennessee. These are the American dog tick, lone star tick and the brown dog tick (Figure 5-4).

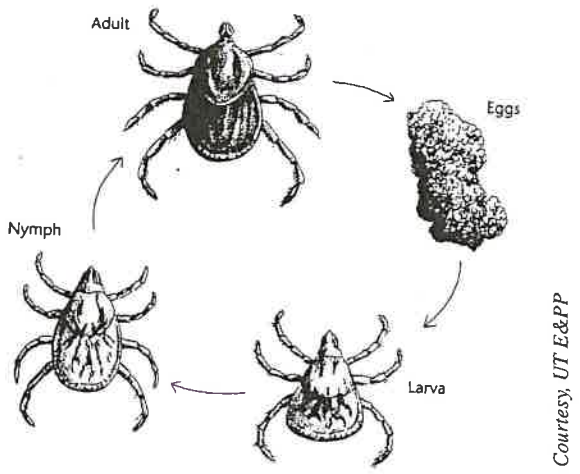


Figure 5-3. Tick life cycle.

The American dog tick (*Dermacentor variabilis*) is a dark brown tick that can be identified by the randomly arranged silver streaks on the back of both the male and female. The immature stages feed primarily on rodents, rabbits, opossums, raccoons, etc., but never on humans. Adults are found on larger animals such as dogs, cattle and humans. The American dog tick is the species that can transmit the Rocky Mountain Spotted Fever (RMSF) organism in Tennessee. Fortunately, even in areas with high rates of RMSF, only 3 to 5 percent of adult ticks carry the organism. This tick attaches to humans most frequently in the spring and early summer. Results of a Tennessee survey indicate the American dog and lone star ticks are well-distributed throughout the state.

The lone star tick (*Amblyomma americanum*) is a reddish brown tick that is slightly smaller than the American dog tick. These ticks have long, large snouts and both sexes have pale markings on the backs. The adult female has a conspicuous white spot on the middle of her back that gives this species its common name. Unlike the American dog tick, all stages of this species will attack people readily. Adults and nymphs are present and searching for hosts as soon as the weather becomes warm in the spring. They decrease in numbers as the summer progresses and are less frequently encountered after early September. The larvae, known as seed ticks, are encountered in masses on vegetation and may result in hundreds of individual bites on one person. Wounds left by attachment of all stages result in discolored itchy spots that may take two weeks to heal. Larval masses are encountered from late July until a killing frost in the fall, but most frequently in August and September. Only those individuals that find a host and feed successfully will pass on to the next stage.

The brown dog tick (*Rhipicephalus sanguineus*) is uniformly dark reddish-brown, similar in appearance to the American dog tick, but smaller and without any light-colored markings on the back. This tick is known to attack dogs and other animals, but rarely humans. It is usually found inside buildings where dogs live, such as houses, dog kennels and runs. It may sometimes be found on porches, in backyards or other sheltered places frequented by dogs. It is usually found in the spring and summer.

Disease Organisms Transmitted by Ticks in Tennessee

Rocky Mountain Spotted Fever is a rickettsial disease that is the most common tick-transmitted disease in Tennessee. Thirty-seven cases were reported in Tennessee in 1997. This is an overall reduction from previous years due to increased awareness on the part of physicians and the public in general. Rocky Mountain Spotted Fever is characterized by fever, headaches, muscle aches, malaise and a rash that starts on the hands and feet. *Dermacentor variabilis* is the vector in Tennessee.

Human Monocytic Ehrlichiosis, or HME, is a new disease that is probably transmitted by the lone star tick. Four cases were reported in Tennessee in 1997. HME has many of the same symptoms as Rocky Mountain Spotted Fever, but usually not with the spots or rash.

Lyme Disease is transmitted by *Ixodes scapularis*, a tick that is rarely encountered in Tennessee. Lyme Disease is most

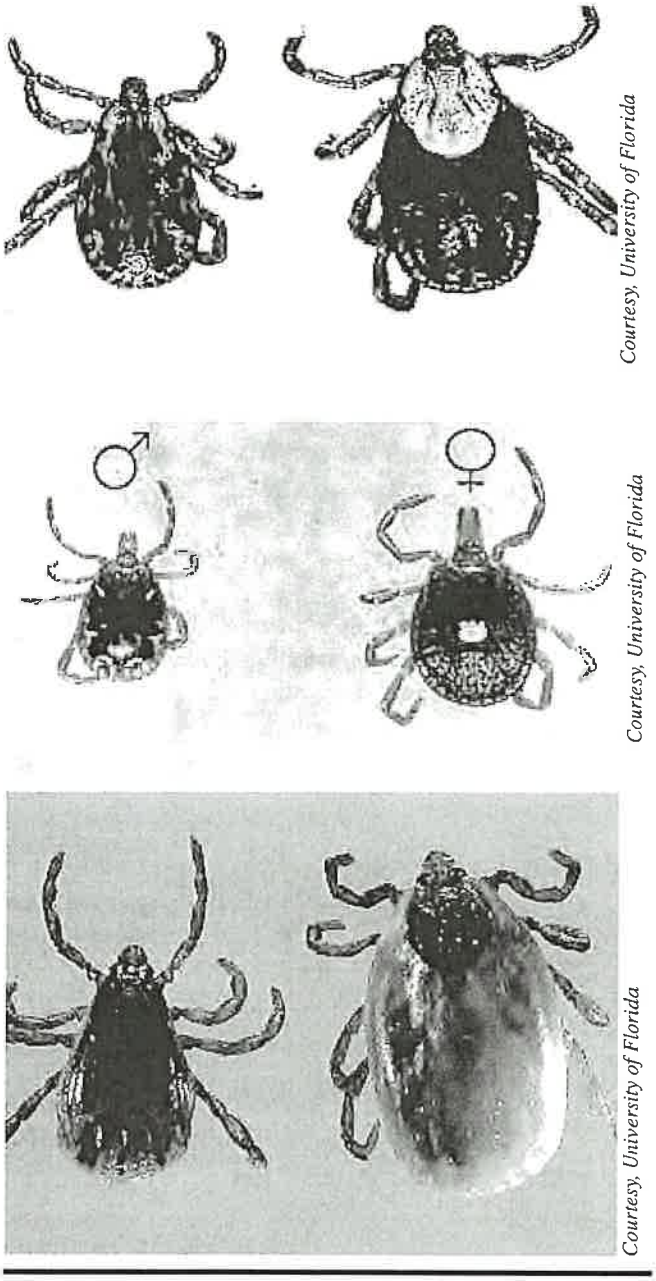


Figure 5-4. American dog tick (top), lone star tick (middle) and brown dog tick (bottom).

often encountered in the New England states, the upper Midwest, mid-Atlantic states and California.

Removing Ticks

The only effective way to remove a tick attached to a person is with a pair of tweezers. Grasp the head region of the tick as close to the skin as possible. Apply firm, steady pressure to remove the embedded mouthparts. Treat as you would any other type of skin wound. Do not crush the removed ticks with either fingers or thumbnails. Do not attempt to remove ticks with nail polish, alcohol or lighted cigarettes.

Be sure to inform your physician of any tick-bite history in the event of illness within one month of a known tick bite.

The only practical way to avoid contracting a disease from ticks is to avoid the tick or to remove the tick as soon as possible.

People living in or visiting in tick-infested areas, such as uncut fields, brushy and other overgrown areas, should inspect themselves, their children and their pets for ticks once or twice a day. Special attention should be given to the hairy parts of the human body and areas where clothing fits snugly. The sooner a tick is removed, the less the chances for transmitting a disease.

Management of Ticks

Overall, a tick control program should include avoidance of infested areas, applying repellent before entering environments that harbor ticks, inspecting for ticks, modifying the environment so it is less conducive to tick survival, and if necessary, applying pesticides to pets and areas frequented by pets.

Protecting people Repellents containing ingredients such as DEET or permethrin applied according to the label instructions to boots, shoes and pants before venturing outdoors will provide some protection. Pants should be tucked into socks or boots to prevent ticks from crawling under the pants and up the leg. DEET may also be applied to skin, but may cause allergic reactions. Avoid eyes, nose, lips, cuts and scratches and other sensitive areas when using repellents, and always apply the repellent according to the label. The CDC recommends using concentrations of up to 30 percent DEET on children over 2 months of age (http://www.cdc.gov). If an allergic reaction is suspected from a repellent, wash the area with soap and water and seek medical attention.

Modifying the environment Nonchemical methods for reducing tick problems include mowing the lawn and controlling weeds. This has three advantages: (1) it lowers the moisture in the grass microclimate and allows sunlight to penetrate, which tends to cause ticks to dry out; (2) it discourages rodents (which may serve as hosts) from nesting; and (3) because there is less plant matter, less pesticide may be needed if a treatment is necessary. Also, removing debris, wood piles or clutter from around the house discourages rodents from nesting. Repair entry points into the house to discourage possible tick hosts from entering. Cracks and crevices, both indoors and out, can be sealed to reduce hiding places for the tick. Inspect and clean pets and their bedding frequently. If bedding is infested, it should be cleaned or destroyed.

Pets A variety of formulations for pets are available from veterinarians. Cats and some breeds of dogs are sensitive to insecticides. Be aware that kittens, puppies and lactating or pregnant females are not always listed on the pesticide label. Always read the pesticide label before using any product to ensure your pet is not excluded. It is a good idea to check with a veterinarian before deciding on a pet treatment.

Products containing fipronil are available from veterinarians to kill ticks on pets. Some are applied as a spot on the pet between the shoulder blades. Most pet owners are satisfied with the control provided by these products.

Collars containing amitraz are another option for tick control on dogs. Insecticides are impregnated into the collar and are spread throughout the pet's hair by grooming. Check

the label for the prescribed treatment time. Prolonged use of a tick collar can cause dermatitis under the collar if a rash occurs.

The number of on-animal, over-the-counter insect control products has increased tremendously in the past few years. Products containing pyrethrin, permethrin and others are available in sprays, collars, dips, dusts, powders, foams, mousses, shampoos and spot-ons.

Outdoors Insecticides should only be applied when ticks are present. In the spring, survey suspected areas by dragging a 3-foot by 3-foot white flannel cloth along the ground. If ticks are found, use a single insecticide application in late April or May to effectively control nymphal and adult lone star ticks and adult American dog ticks. Survey again in August or September for newly-hatched lone star seed ticks and apply an insecticide to appropriate areas.

Where tick populations are high, outdoor areas that may need treatment include vegetation along borders, areas between woods and lawn, around ornamental plantings, fence lines, etc. Make sure the plants to be treated are listed on the label to prevent plant injury. Ticks avoid direct sunlight, so treating the entire lawn is not usually needed. Areas where dogs frequent should also be treated. Products labeled for outdoor use are not usually labeled for treating pets! Pesticide applications beyond a barrier treatment of the structure will require the technician to be certified in category 3 and under the supervision of a person licensed in HLT.

Indoors Tick control is seldom needed indoors in Tennessee because the most common species, the American dog tick and the lone star tick, are seldom found indoors. Indoor treatment is needed if the pet is infested with brown dog ticks, although this is relatively rare. Brown dog ticks will feed on the pet and drop off to molt in the many cracks and crevices available in the home. These ticks are difficult to control because they can survive several months without another blood meal. If brown dog ticks are found, frequently inspect and remove ticks from pets. Vacuum rugs, floor, furniture, baseboards and behind furniture. Insecticides should be applied to cracks and crevices, such as along baseboards and molding, around door and window frames, underneath furniture, beneath the edges of carpeting, behind loose wallpaper and in other tight spots. Treat these cracks and crevices with dusts or sprays.

Because ticks tend to crawl up walls, treat up high as well as low. Concentrate on areas where the pet rests. Dust or spray cracks and crevices in crawl spaces if pets have access to this site. Retreatment may be necessary as eggs and immatures hatch and emerge from hiding places.

Mites and Chiggers

Bird and Rodent Mites

Parasitic mites (Figure 5-5) that occasionally infest buildings are usually associated with wild or domestic birds or rodents. Bird and rodent mites normally live on the host or in their nests, but migrate to other areas of the structure when the animal dies or abandons the nest. Rodent mites often become a nuisance after an infestation of mice or rats has been eliminated. People usually become aware of the problem when they are attacked by mites searching for an alternate food source. Their bites cause moderate to intense itching and irritation. Rodent and bird mites are very tiny, but usually can be seen with the naked eye. They are about the size of the period at the end of this sentence.

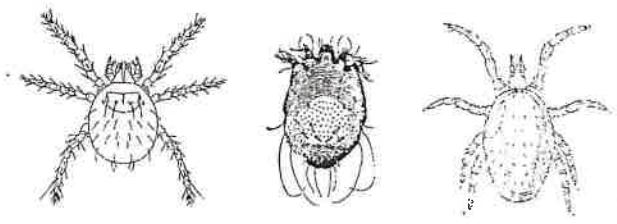
The first step in controlling bird or rodent mites is to remove the host animals and their nesting sites. Often, the nests will be found in the attic, around the eaves and rafters, or in the gutters or chimney. Gloves should be used when handling dead animals. A respirator should also be worn when removing nest materials to avoid inhaling fungal spores and other potential disease-producing organisms associated with the droppings. See the CDC Web site for directions to safely remove feces.

After nests are removed, the areas adjacent to the nest should be sprayed or dusted with a residual insecticide. Space or ULV treatments with non-residual materials (e.g., synergized pyrethrins) can be used in conjunction with residual sprays. Space treatments are especially useful when the mite infestation has dispersed widely from the nesting site. In this case, more extensive treatment with residual and non-residual insecticides may also be necessary in other areas of the structure where mites are observed. A vacuum cleaner or moistened cloth can be used to eliminate mites crawling on open surfaces.

Chiggers

Chiggers are the larvae of a mite family sometimes called red bugs. Chiggers are extremely small (0.5 mm) and are difficult to see without magnification. The six-legged larvae are hairy and yellow-orange or light red. They are usually encountered outdoors in low, damp places where vegetation is rank and grass and weeds are overgrown. Some species also infest drier areas, however, making it difficult to predict where an infestation will occur.

Chiggers overwinter as adults in the soil, becoming active in the spring. Eggs are laid on the soil. After hatching, the larvae crawl about until they locate and attach to a suitable host. The larvae do not burrow into the skin, but inject a salivary fluid that produces a hardened, raised area around them. Body fluids from the host are withdrawn through a feeding tube. Larvae feed for about four days and then drop off and molt to nonparasitic nymphs and adults. Chiggers feed on a variety of wild and domestic animals, as well as humans. The life cycle (from egg to egg) is completed in about 50 days.



Courtesy, University of Kentucky

Figure 5-5. Parasitic mites on humans (from left to right) chigger, scabies and bird mite.

Most people react to chigger bites by developing reddish welts within 24 hours. Intense itching accompanies the welts, which may persist for a week or longer if not treated. Bites commonly occur around the ankles, waistline, armpits or other areas where clothing fits tightly against the skin. Besides causing intense itching, chigger bites that are scratched may result in infection and sometimes fever. Chiggers in North America are not known to transmit disease.

Persons walking in chigger-infested areas can be protected by treating clothing (cuffs, socks, waistline, sleeves) or exposed skin with tick repellents. Some repellents should only be used on clothing; and it is important to follow label directions. People who suspect they may have been attacked by chiggers should take a soapy bath immediately and apply antiseptic to any welts. A local anesthetic will provide temporary relief from itching. Regular mowing and removal of weeds and brush make areas less suitable for chiggers and their wild hosts. Mowing also enhances penetration and performance of miticides, should they be required. Chigger populations can be further reduced by treating infested areas with residual miticides, but individuals using pesticides on the landscape must be under the supervision of a licensed HLT operator. Applications should be thorough but restricted to areas frequented and suspected of being infested.

Bed Bugs

There are several species of bed bugs, all of which are parasites of warm-blooded animals. Until recently, the common bed bug, whose preferred host is humans, was rarely encountered. Bed bugs are now becoming more common. Related species, such as the bat bug and bird bug, prefer to feed on bats, birds and other wild hosts but will also feed on humans if the opportunity arises or the preferred host dies or leaves the roost. Adult bed bugs are about 1/4-inch long and reddish brown, with oval, flattened bodies (Figure 5-6). Bed bugs prefer to hide in cracks and crevices during the daytime and come out to feed on the host's blood at night, usually while the host is sleeping. Infestations are usually detected by the welts and irritation caused by the bites and by the fecal smears and blood spots visible on pillowcases, sheets and mattresses. Heavy infestations of bed bugs may also be accompanied by a distinct odor.

The key to controlling bed, bird and bat bugs is to locate and treat all cracks and crevices where the bugs may be hiding. Typical hiding places are in the tufts, folds and seams of mattresses and the cracks in the box spring and bed frame. Only a few products are labeled to treat mattresses, so read the label carefully before making applications. With permission from the client, fabric under the bedspring can be partially removed and the bed bugs vacuumed. Heavier infestations often spread to behind baseboards, window and door casings, behind pictures, electrical switch plates, loose wallpaper, in the pleats of drapes, the upholstery of furniture and many other cracks and crevices. When inspecting for bed bugs, look for the insects themselves as well as the telltale fecal and blood spots indicating that a hiding place is nearby.

Do not spray sheets or blankets. Some pest management professionals will not treat mattresses with insecticides because of the potential human exposure while others will cover treated mattresses and box springs with a plastic allergen-prevention cover after treatment. Others may physically remove bed bugs with vacuums and/or steam cleaners and then cover the bed with an encasement (i.e., Protect-A- Bed by Residex). This mattress encasement makes future inspections easier too. Some insecticides may need to contact bed bugs directly to be effective. Incorporating nonchemical controls including vacuuming, low moisture steaming (AmeriVap, Hi-Tec Cleaning Systems, etc.) laundering, and removal of infested items may be necessary to manage bed bugs and may be more important as resistant bed bug population are encountered.

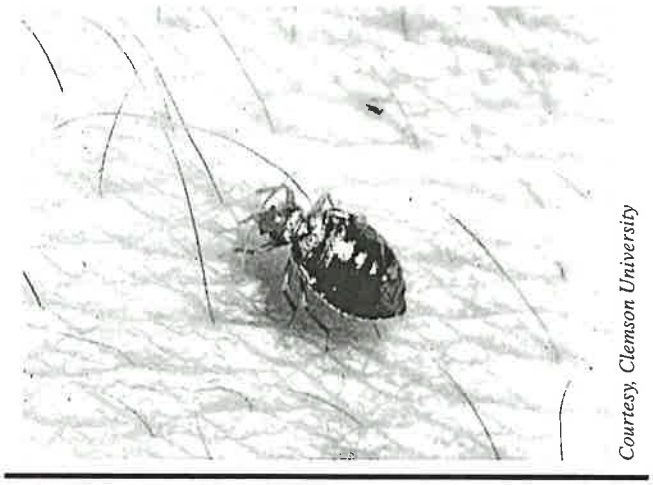

Courtesy, Clemson University

Figure 5-6. Bed bug.

Following thorough inspection/treatment of living areas, efforts should be made to locate and eliminate potential wild animal sources of infestation. These may include birds, bats or squirrels in the attic, or possibly mice or rats. If bat bugs or bird bugs are found in these areas, residual and non-residual insecticides should be applied, and the wild hosts excluded. Often two or three treatments are required to eliminate an infestation. More information on bed bugs and their management can be found in **PB1763 Bed Bugs: Making a Comeback in Tennessee Too!** Current pesticide recommendations are listed in the UT E&PP's **Redbook** located at http://eppserver.ag.utk.edu/redbook/sections/structural.htm.

Wasps, Hornets and Yellow Jackets

Wasp, hornet and yellow jacket stings are a serious health threat to humans and animals. Hundreds (perhaps thousands) of people in the United States die each year from allergic reactions to the venom of these insects. Wasps, hornets and yellow jackets are more dangerous and unpredictable than honey bees. Workers foraging away from the nest are seldom aggressive, but nests should be eliminated with great care and in a specific manner. "Folk" remedies, such as dousing nests with gasoline or a garden hose, seldom work and can result in multiple stings.

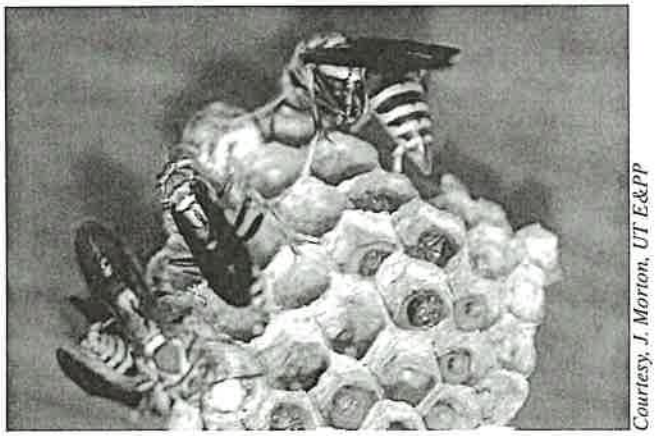


Figure 5-7. Paper wasp.

Figure 5-8. Yellowjacket wasp.

Types of Wasps

Paper wasps Paper wasps (as well as hornets and yellow jackets) construct nests of a paper-like material containing finely chewed wood fragments and salivary secretions of the wasps. Paper wasps typically build their umbrella-shaped nests under eaves and ledges (Figure 5-7). These brownish wasps are not as aggressive as yellow jackets or hornets and can be eliminated rather easily with a wasp and hornet spray aerosol. One advantage of these formulations is that they can be sprayed as far as 20 feet.

Although it is best to treat all wasps at night, paper wasps can be eliminated during the daytime provided you do not stand directly below the nest during treatment. Most wasp sprays cause insects to drop instantly. Standing directly under a nest increases the risk of being stung. After treatment, wait a day to ensure that the colony is destroyed, then scrape or knock down the nest. This will prevent secondary problems with carpet beetles and other insects.

Hornets Hornets are far more difficult and dangerous to control than paper wasps. The European hornet, *Vespa cabro*, is the only true hornet in Tennessee. Bald-faced hornet nests resemble a large, grey, bloated football, which typically is attached to a tree, bush or side of a building. European hornets build a brown carton nest. Hornet nests may contain thousands of wasps that are extremely aggressive when disturbed. The nests are often located out of reach.

Treat hornet (except European Hornet) and yellow jacket nests at night when most wasps are within the nest and the colony is less active. A full wasp suit, sealed at the wrists, ankles and collar, should be worn. Apply an aerosol-type wasp and hornet spray or a dust formulation directly into the nest opening. Hornet nests have a single opening, usually toward the bottom, where the wasps enter and exit. It is critical that the paper envelope of the nest not be broken during treatment or the irritated wasps will scatter in all directions, causing even greater problems. Following treatment, wait at least a day before removing the nest to ensure that all of the wasps are killed. If hornets continue to be observed, the application may need to be repeated.

European Hornets are active at night and are attracted to lights. The best time to treat these colonies is just before sunrise, but while it is still dark. See Extension factsheet **SP290-A, European Hornets Tapping at Your Window at Night?**, available from your county Extension office for more information.

If the nest is located away from frequently used areas, another option is to wait and do nothing. In Tennessee, wasp, hornet and yellow jacket colonies die naturally after the weather turns cold, and the paper carton disintegrates over the winter months. Newly mated queens survive the winter.

Yellowjackets Yellowjackets (Figure 5-8, and Table 5-2) are often considered the most dangerous stinging insects in the United States. They tend to be unpredictable and usually will sting if the nest is disturbed.

Yellowjackets form annual colonies in Tennessee (Figure 5-9). Mated queens overwinter under bark and in other sheltered locations. In the spring the queen emerges and constructs a small paper nest in which she lays her eggs. Larvae are fed by the queen, and in about a month, emerge as sterile adult females called workers. The newly-emerged workers assume all nest activities except egg laying. Thereafter, the colony grows rapidly, containing up to 4000 workers by the end of the summer. New males and queens are produced in late summer to early fall. After mating, the colony dies off and the newly fertilized queens seek out sheltered sites for overwintering. Abandoned nests are not reused and soon disintegrate.

Yellowjacket nests are often located underground in old rodent burrows or beneath rocks or landscape timbers. Yellowjackets also build nests in walls, attics, crawlspaces and behind the siding of buildings. If the nest can be located, it can usually be eliminated by carefully applying a wasp spray insecticide into the nest opening. Dust formulations are also very effective, provided a hand duster or similar type applicator is used to dispense several puffs of insecticide dust into the nest opening.

Treatment should be performed late at night after all yellowjackets are in the nest and less active. Pinpoint the nest opening during the daytime so you will remember where to direct your treatment after dark. Approach the nest slowly and do not shine the beam of your flashlight directly into the nest entrance as this may startle the wasps; instead, cast the beam to the side to illuminate the nest indirectly. If possible, place the light on the ground rather than in your hand as wasps

Table 5-2. Tennessee yellowjackets and hornets.

Species and distribution in Tennessee	Gaster and other images	Identifying characters of workers	Typical (and maximum) # of workers, cells and combs	Nest description and location	Feeding behavior and other biology	Pest status and other information
Vespa crabro, European hornet East and Middle Tennessee		>20 mm; first abdominal segment reddish-brown; yellow markings; wings brownish and eyes red.	200 – 400 (1000) workers; 1500 – 3000 cells in 6 – 9 combs	Brown carton nest constructed in hollow trees, roofs, attics, wall cavities, bee hives; subterranean nests may be found.	Active at night, attracted to light, tap on windows.	A very defensive species. Can girdle trees for sap and fibers. See Extension factsheet SP290-A for more information. Only true hornet in Tennessee.
Dolichovespula artica East Tennessee		No worker caste, use workers of host species mentioned below	Variable	Obligate social parasite of *D. arenaria* and *D. norvegicoides*. Males of host often produced in great numbers when parasite queen killed.		
Dolichovespula arenaria, aerial yellowjacket East and Middle Tennessee		Broad space between compound eyes and base of mandibles; yellow genal band continuous; yellow of terga I and II deeply notched	200 – 700 workers; 39 – 4359 cells in 1 – 6 combs; multiple brood cells	Nests often constructed in vegetation (few cm – tree tops) and on man-made structures – houses, sheds, garages; subterranean nests may be found.	Do not scavenge protein, so not usually picnic pest; decline in Aug., few endure through Sept.	Common; May buzz heads for long distances in woods; can spray venom from sting; large colonies formidable; control warranted if nest near people.
Dolichovespula maculata, baldfaced "hornet" all Tennessee		>15 mm; gaster mostly black; white markings on last 3 terga	100 – 400, 636; about 2000 (3500) cells in 3 – 4 combs	Nests (>35 cm diameter and >60 cm long) usually in exposed locations: vegetation up to 20 m, rock overhangs, electric power poles, houses, sheds, etc.	May scavenge protein, but mostly feed on live prey (flies, yellowjackets, etc)	Common; not as defensive as *Vespula*; should be regarded as a beneficial insect unless colony near people.
Dolichovespula norvegicoides East Tennessee		Broad space between compound eyes and base of mandibles; yellow genal band widely interrupted; yellow of terga I and II not deeply notched	23 – 50 workers, 230 cells in 2 combs	Only a few nests recorded; 10 – 15 cm off ground in vegetation.	Not much known about this species.	Not very common; East Tennessee is southern most portion of eastern range
Vespula consobrina, blackjacket East Tennessee		Area under compound eyes touching or nearly touching base of mandibles; black with white markings; white band on tergum I interrupted	Small; <100 workers; 490 – 1437 cells in 2 – 4 combs (1 worker comb and 1 – 3 reproductive combs)	Nests usually subterranean rodent burrows in forests, but may be in logs or rock cavities or walls of houses.	Forage for live prey, including spiders and insects. Workers will defend food source from other yellowjackets.	Colonies declining and producing reproductives by Sept. in North Carolina. Responsible for numerous stinging episodes to loggers in western North Carolina.

Table 5-2. Tennessee yellowjackets and hornets.

Species and distribution in Tennessee	Gaster and other images	Identifying characters of workers	Typical (and maximum) # of workers, cells and combs	Nest description and location	Feeding behavior and other biology	Pest status and other information
Vespula vidua East Tennessee		Area under compound eyes touching or nearly touching base of mandibles; first antennal segment yellow ventrally	One colony had 385 workers; 2,447 cells; one worker comb and 1 – 3 reproductive combs	Nests in disturbed areas (yards, pastures, as well as forests); most nests subterranean, but also in logs and artificial structures.	Pests around picnic tables as capturing insects or attracted to odors. Not usually pests unless nest is nearby.	Not a stinging hazard unless located near human activity.
Vespula squamosa, southern yellowjacket all Tennessee		Orange queen; workers with area under compound eyes touching or nearly touching base of mandibles; two yellow stripes on scutum (thorax)	500 – 4000 workers; 2,500 – 10,000 cells. new cells grey, V. maculifrons cells smaller and tan	Nests mostly in disturbed areas (yards, parks, roadsides); sometimes in pine or mixed forests, rarely in hardwoods. Most nests subterranean, but aerial or structural nests found especially when associated with *V. maculifrons.*	Workers scavenge protein and are nuisances at picnics. Queen usurps *V. maculifrons* nest often.	Important pest because nests found in urban and recreational areas. Disturbances of these large nests usually results in multiple stings.
Vespula flavopilosa, hybrid yellowjacket East Tennessee		Area under compound eyes touching or nearly touching mandible base; medial black mark on tergum I "V"-shaped	500 – 1000; 2000 – 5000 cells (20% queen cells); colonies smaller than *maculifrons*	Subterranean nests of tan, fragile carton. Nests established along roadsides and in yards and several have been found in structures.	Scavengers; May leave stingers behind at sting site; stingers confused with honey bee stingers.	Life cycle completed by early October (1 mo. earlier than *V. maculifrons*) in western North Carolina. Not as common as *V. maculifrons.* Pest at picnics.
Vespula germanica, German yellowjacket		Area under compound eyes touching or nearly touching base of mandibles; medial black mark on tergum I diamond-shaped	In U.S., one nest had 11,540 cells	In U.S., almost all nests have been in structures with a majority between walls.	Scavenge proteins and attracted to sweets, wide variety of arthropod prey.	Significant pest problem where found. Colonies in Mid-Atlantic may be active into December. Problem to beekeepers also.
Vespula maculifrons, eastern yellowjacket all Tennessee		Area under compound eyes touching or nearly touching base of mandibles; medial black mark on tergum I anchor- shaped	Large colony 3000 – 5000 at peak, 10,000 – 15,000 cells of which 30% are queen cells	These tan-brown fragile nests usually found in subterranean locations in yards, roadsides, urban areas and especially in creek banks of hardwood forests. Also found in rotten stumps, walls of structures and vehicles.	Prey upon insects, scavenges.	In Georgia, reproductives found in late September and continues into December. Competes for primary pest status with *V. squamosa.*
Vespula vulgaris, common yellowjacket East and Middle Tennessee		Area under compound eyes touching or nearly touching mandible base; yellow genal band interrupted with black, sometimes only slightly	Data from Western U.S.: 3,000 +; 2,100 cells, 210 reproductive	Predominately subterranean nest in rotted logs, leaf litter and soil. Colonies found in walls: nest envelope and comb constructed of decayed wood fragments and are red to tan-brown and very brittle.	Feed on a variety of immature insect prey and scavenge any protein or sugar source.	Important nuisance pest at picnics.

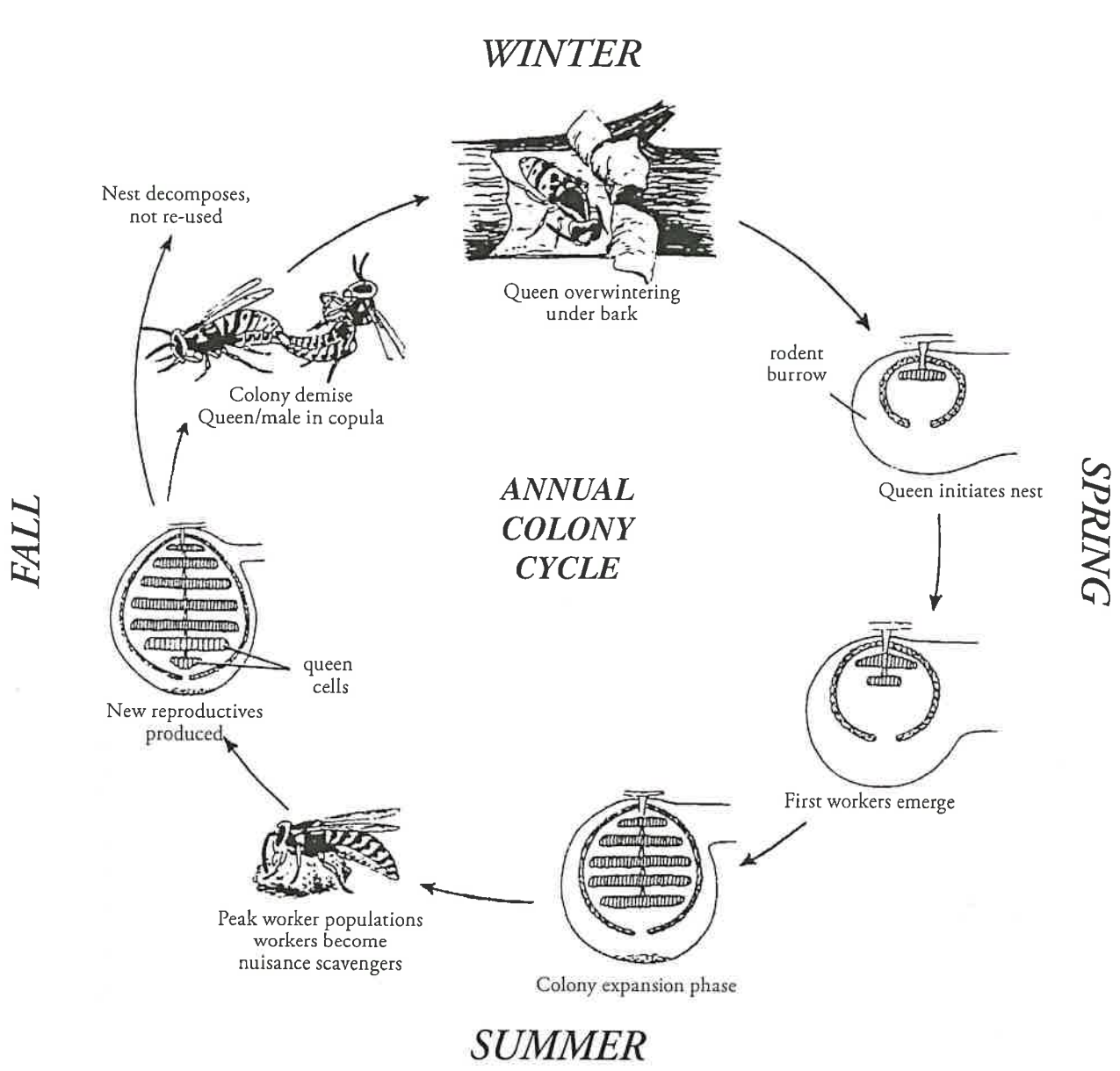


Figure 5-9. Yellowjacket life cycle.

tend to fly toward the light. As with hornets, yellowjackets are extremely aggressive when the nest is disturbed. Colonies are smaller in the spring, so control is easier at that time.

Late-summer foraging activity During late summer and fall, yellowjacket colonies are nearing maturity and huge numbers of workers are out foraging for food for the developing queens. Late in the year, feeding preferences shift in favor of available sources of sugar, including fruits, ice cream, soft drinks, beer or other sweets. The persistent foraging of yellowjackets at picnics and other outdoor activities produces many calls from homeowners and businesses wanting to know what can be done to alleviate the problem. Options include:

Sanitation The best way to reduce the threat of foraging yellowjackets is to minimize attractive food sources. People eating outdoors should keep food and beverages covered. Spills and leftovers should be cleaned up promptly. Trash cans should be equipped with tight-fitting (preferably self-closing) lids. Similar sanitation recommendations should be made to commercial establishments, including ice cream parlors, outdoor cafes and supermarkets. Whenever possible, trash cans and dumpsters should be located away from serving tables, loading dock doors and other entrances. Trash cans should be equipped with a plastic liner and emptied and cleaned frequently. Maintaining high levels of sanitation earlier in the summer will make areas less attractive to yellowjackets later in the year. This strategy is especially useful for parks and recreation areas.

Avoidance Combined with sanitation, this is the best advice in most situations. Yellowjackets foraging away from their nests are seldom aggressive and usually will not sting unless provoked. People should resist the temptation to "swat" at the wasps — and be careful when drinking from beverage cans which may contain foraging individuals. Avoidance may also be the best advice if a yellowjacket (or hornet) nest is located in a tree or other out of the way location. As noted earlier, yellowjacket colonies die off on their own in mid-late autumn.

Traps Although only of marginal benefit, traps are available that can catch impressive numbers of yellowjackets when properly baited and positioned. Business establishments, such as outdoor cafes, may find these traps worthwhile when used with other approaches. braunschweiger liverwurst spread combined with jelly has been an effective attractant.

Allergic Reactions

Wasp, hornet and yellowjacket stings can be life-threatening to persons who are allergic to the venom. People who develop hives, difficulty breathing or swallowing, wheezing or similar symptoms of allergic reaction should seek medical attention immediately. Itching, pain and localized swelling can be somewhat reduced with antihistamines and a cold compress.

Spiders

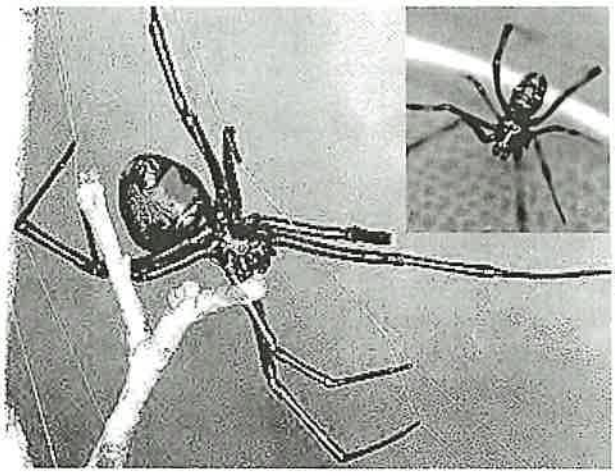
Many different kinds of spiders live in and around buildings. Some, such as garden and cellar spiders, construct webs to help entrap their prey. Others, including the wolf spiders, are free-roaming and make no webs. Most spiders are harmless, and in fact are beneficial, because they prey upon flies, crickets and other insects. They generally will not attempt to bite humans unless held or accidentally trapped. Moreover, the majority of spiders have fangs too small or weak to puncture human skin. Of the hundreds of species found in Tennessee, the black widow and brown recluse are considered the most dangerous. Fortunately, they have markings that can be used to distinguish them from other non-threatening species.

Types of Dangerous Spiders

Black widow spider Of the spiders capable of inflicting a poisonous bite, black widows are the most notorious. The female is about 1 1/2 inches long, shiny black and usually has a red hourglass mark on the underside of the abdomen (Figure 5-10). In some varieties the hourglass mark may be reduced to two separate spots. Spiderlings and male spiders are smaller than females and have several red dots on the abdomen's upper side.

Black widow spiders belong to the cobweb spider family and spin loosely organized trap webs. The webs are usually found outdoors under objects such as rocks and ground trash or under an overhanging embankment. Black widow spiders are not as common in homes as the brown recluse. When found in homes, they are usually under appliances or heavy furniture and not out in the open like other cobweb spiders. Black widow spiders are timid, however, and will only bite in response to being injured. People are usually bitten when they reach under furniture or lift objects under which a spider is hiding.

Black widow venom is a nerve toxin and its effects are rapid. The victim suffers painful rigidity of the abdomen and usually a tightness of the chest. Blood pressure and body temperature may rise and sweating, localized swelling and a feeling of nausea may occur. In about 5 percent of the bite cases the victim may go into convulsions in 14 to 32 hours and die if not given medical attention. First aid for black widow spider bites involves cleansing the wound and applying ice packs to slow



Courtesy, University of Florida, UT E&PP (insel)

Figure 5-10. Black widow adult. Immatures and males may have red dots on the upper abdomen (insert).

absorption of venom. Victims should seek medical attention promptly. An antivenom is also available for severe cases.

Brown recluse spider Few things cause as much fear and anxiety in people as the thought of poisonous spiders. Arachnophobia, irrational fear of spiders, is widespread in the United States. The brown recluse spider (Figure 5-11) is one of the feared poisonous spiders occurring in Tennessee. This spider is often visualized as an aggressive, bad-tempered monster, just waiting for an opportunity to ambush people. In reality, the brown recluse spider is a shy, retiring spider that does not attack people and usually only bites in response to being injured. Most reported bites occur when putting on old clothing in which the spider is hiding or rolling over on a spider in bed. The brown recluse spider lives up to its name. Most people living in proximity to the spider will never see it, nor be bitten by it.

The brown recluse *Loxosceles reclusa* is a medium-sized spider. The adult body ranges from 7mm to 12mm in length (1/4 to 1/2 inch) and 3mm to 5mm wide (1/8 to under 1/4 inch). The legs span an area roughly the size of a quarter to a half-dollar.

The color of the brown recluse varies from a light yellowish brown to a dark, reddish or chocolate brown, but most are light to medium brown. Their body is densely covered by short hairs, and the male abdomen is generally smaller than that of the female. The second pair of legs are longer than the remaining pairs in both sexes. Three pairs of eyes are arranged in a semicircle. Since most other spiders have eight eyes, this feature alone can eliminate many specimens suspected of being a brown recluse spider.

The most distinguishing characteristic is the violin-shaped marking on the carapace (the top of the body directly above the legs). Although variable, the violin-shaped marking is usually much darker than surrounding areas and may appear longitudinally lined. In some individuals, the size of this violin-shaped marking may be considerably reduced. Other spiders may have a violin-shaped marking. The best identification feature for the brown recluse is the semicircular arrangement of the three pairs of eyes. Contact your county Extension agent to identify a suspected brown recluse spider.

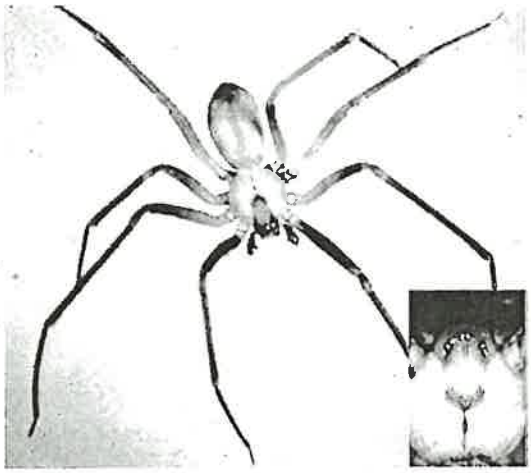
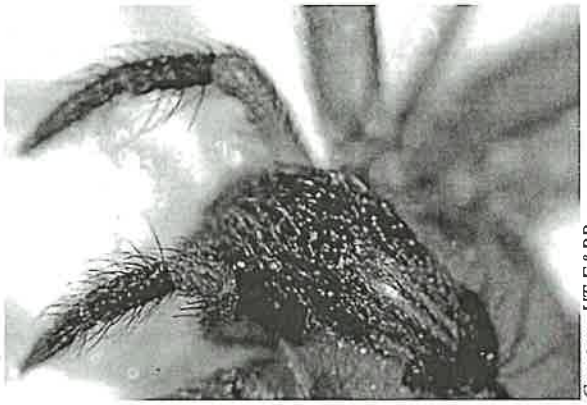


Figure 5-11. Brown recluse male. Brown recluse are easily identified by 3 pairs of eyes in a semi-circular arrangement (insert).

Courtesy, UT E&PP

Figure 5-12. Enlarged pedipalps of a male brown recluse.



Courtesy, UT E&PP

Figure 5-13. Slender pedipalps of a female brown recluse.

Habitat Brown recluse spiders prefer sheltered areas with low moisture levels. They have been found under loose bark, in hollow logs and under stones. People have created many new habitats that these spiders have successfully exploited. They have been found in all types of buildings. In homes, they tend to prefer darkened storage areas in closets, garages, basements, attics and cupboards. The following list includes many of their preferred hiding places: in utility boxes, under bridges, inside barn walls, under hay bales, in drainage passages under roads, among feed sacks, under inner tubes, under houses, under furniture, behind picture frames, in underground pump houses and cold storage cellars, under and in boxes, among papers, in clothing hanging on walls, under boards, in firewood stacks, in demolished houses, under piled bricks, in kitchen cabinets and other seldom disturbed and sheltered places.

Web The brown recluse spider builds irregular, patternless webs in poorly-lighted areas. There is usually a thicker portion of web (sometimes almost tubular) built in a protected area such as in a crevice or between two rocks. The spider will retreat to this area of the web when threatened. The silk web is sticky when new, but loses this feature with time, primarily due to dust accumulation. Silk webs are laid down as the spider walks, and the web becomes thicker. Webs can eventually become sheetlike if located in an area of abundant prey.

Feeding Brown recluse spiders feed on a variety of insects, other arthropods and occasionally another spider. Their bite quickly paralyzes prey, which may remain alive for a few days until the spider decides to feed on it. The spider is alerted to the presence of prey by web vibrations caused by passing prey. However, there is some evidence that the brown recluse spider might forage short distances from the web at night. Prey is located and bitten, but not wrapped in silk.

Life cycle The brown recluse spider has been known to live up to two years in captivity. It is quite possible that they may go through two winters in outdoor conditions. Some scientists believe brown recluse spiders may live five to 10 years under ideal conditions. These spiders develop egg sacs between February and September, with most development from May through July. Each egg sac normally contains between 20 and 50 eggs. The female usually constructs up to five egg sacs. Spiderlings emerge from the egg sac within three to five weeks and stay in the web with the mother for one or two molts (shedding of skins) before migrating to other suitable habitats. The spiderlings molt six or seven times before becoming an adult in the following year.

Distribution The brown recluse spider is found in every county in Tennessee with the possible exception of a few extreme eastern counties. They are far more common in the western half of the state. Their major range extends from central Texas to Alabama, north to southern Ohio and west to southeastern Nebraska, Kansas and Oklahoma.

Venomous bites There are 13 different species of *Loxosceles* in the United States and four of them, *L. reclusa, L. deserta, L. laeta and L. rufescens,* have been associated with human reactions. The brown recluse spider, *Loxosceles reclusa*, typifies the species, and is widely distributed throughout the Midwest, Southwest and particularly throughout Tennessee. Often called the violin or fiddle-back spider because of the violin-shaped figure on its dorsal cephalothorax, it varies in size depending on diet and habitat.

Since most brown recluse spiders hibernate in the winter (except those which live indoors), most bites occur between

March and October when humans accidentally disturb their habitat: closets, outbuildings or woodpiles. Despite their usual timid nature, these spiders are inherently more dangerous than other spiders because they have adapted their habitat to live in close association with people.

Often initially painless, the bite wound starts with a central pimple and produces an irregular red reaction in 6-12 hours, followed by blister formation and/or skin death. The resultant skin ulcer heals slowly and may require skin grafts or flaps to reconstruct the defect. Tissue examination of the lesions demonstrate acute blood vessel injury and white cell infiltration. The initial bite is often asymptomatic and may be difficult to diagnose clinically unless the patient saw the spider. Often these bites are confused with wasp or bee stings, tick bites, allergic reactions or skin abscesses. The resulting lesion often becomes painful and/or itchy. Case reports of blood abnormalities, kidney failure or death have been recorded.

The venom of the brown recluse spider contains at least nine protein fractions identifiable by molecular weight on gel electrophoresis. One major protein is a phospholipase enzyme. This venom fraction aggregates platelets, induces white blood cells to enter the wound, liberates inflammatory mediators and produces skin lesions when injected into rabbits.

The treatment of brown recluse spider bites remains controversial. Rest, Ice Compressions and Elevation (RICE) have been useful in reducing redness and swelling. Antihistamines can be used for itching and analgesics, as appropriate, for pain control. Antibiotics used systemically seem to reduce the incidence of secondary infections. A baby aspirin taken the first day of the bite, if there are no contraindications, is helpful to reduce clotting within the blood vessels. Tetanus toxoid should be given as for a dirty wound. A drug called dapsone can be used in severe or progressing bites. Steroids should be reserved for patients with significant generalized symptoms such as rash and blood hemolysis. Excising the bite site acutely should be avoided since the inflammatory reaction produced by the venom will inhibit wound healing and produce inferior clinical results. Plastic surgical procedures can be helpful for reconstructing the wound site after the active phase of tissue damage has been completed. This may take up to 20 weeks.

Avoiding Bites

Most bites occur when the spider is pressed against the skin inside clothing or when rolled on in bed. To minimize bites in homes where brown recluse is present,

1. store clothing in sealed plastic bags or storage boxes,
2. store shoes in plastic shoe boxes,
3. shake clothing and shoes before wearing,
4. move beds away from walls or curtains,
5. remove bed skirts from box springs,
6. do not use bedspreads that touch or come close to the floor,
7. place glue boards under each bed leg, and
8. inspect bedding before climbing into bed.

Management

Sanitation Since the brown recluse spider can live for months without food or water, eliminating the insects on which the spider feeds is not an effective means of control. Removing preferred habitat can reduce population numbers drastically. Remove loose boards, old furniture and other junk from outside areas. Move firewood away from the home, elevate it off the ground and cover it with plastic. Remove all vegetation and mulch at least 18 inches from the foundation to keep spiders away from the foundation. Trim branches of trees and shrubs away from the home to prevent spiders from using them as a guide into the home. Adequately ventilate attics and crawl spaces. Seal all cracks and crevices where spiders may possibly enter the home, including areas where soffit meets wall, and cracks where pipes, cables and wires enter the structure. Also, add door sweeps and weather-stripping around doors and windows as needed and add screening behind all vents in attic and crawl space. Before sealing entry points, a residual insecticide should be applied. Indoors, remove unused boxes and papers, sweep out sheds and attics, clean around water heater compartments and remove old clothing from sheds, barns and attics. If spiders were found in used boxes, all boxes should be inspected and spiders vacuumed as they are found. Wear long sleeves and gloves when performing this task. Also use a vacuum to remove any spiders and their webs found throughout the home.

Monitoring Use sticky traps or mouse-control glue boards, throughout the home to determine spiders' location and abundance. Monitoring traps also help reduce brown recluse populations. Traps should be placed along walls or other edges in areas such as under pieces of furniture; behind toilets, under sinks and bathtubs; in closet floors and on several shelves; on exposed sill plates, in crawl spaces and basements; near stored items in garages and attics, especially around boxes; and near openings of light fixtures and vents in attics. Do not skimp on monitoring traps. They can be fairly inexpensive, so use plenty throughout the structure.

Insecticide Applications

Prior to insecticide applications, vacuum exposed spiders and their webs.

Cracks and voids Because brown recluse prefer cracks and enclosed areas or voids and they tend to be secretive, insecticide applications are best made to these places where they may be hiding. Cracks and voids are best treated with dusts which have a long residual and will coat the surface of the crack or void. Dusts are safer to use around electrical equipment. Using a plastic-tipped duster, voids behind electrical outlets and switches can be dusted. Also, if live spiders are found living under insulation in the attic, a light dusting can be made under the insulation. Dusting on the surface of insulation does not usually provide good results. In attics and crawlspaces, apply dusts into cracks in sill plates and voids of the foundation walls.

Spot treatments Spot treatments of liquid residual insecticides to areas where spiders may crawl are most effective when combined with crack and void treatment. Using only spot treatments will usually result in poor control. Application of liquid insecticides to areas where the wall meets the floor is more effective than applications to open spaces, because spiders are more likely to use the edge of the wall to move. Spray the wall/floor interface near stored items such as boxes.

The sill plate or header of the foundation wall can be sprayed in crawlspaces and basements.

Space treatments Although space treatments with pyrethrins or resmethrins are effective against flying insects, when used for brown recluse control they may flush the spiders from their hiding places onto surfaces that have been treated with residual insecticides. It is important to direct the space spray at areas suspected of harboring brown recluse.

Exterior treatments As we said earlier, removing harborage sites will reduce spider populations outdoors. Cracks in exterior walls should be treated with an insecticidal dust mentioned above and then sealed. Weep holes behind brick veneer can either be treated with insecticide dust alone or an application of a nonresidual insecticide from an aerosol-generating machine followed by a residual dust treatment. Screens can be placed in the weep hole to prevent spider entry and still allow moisture to escape. If infestations are severe and there is a high probability that reinfestation will occur from the outside, then a perimeter treatment may be applied to the exterior foundation and ground away from the home.

A great deal of effort is needed to effectively control brown recluse spiders. Treatments applied for control will probably make the spiders more active. Therefore, it is imperative that dwellers be advised on strategies to avoid bites.

Itches, Irritations and Delusions

Once in a while, nearly everyone experiences the irritation of an unexpected itch or the sensation of something crawling over the skin. Other times, the irritation may feel more like an insect bite. These reactions can become so annoying for some people that they are forced to seek professional help. Even though actual pests may not have been observed, the irritation is often attributed to "bugs," and an insecticide is applied in the hope that the problem will be resolved. Unfortunately, pesticides seldom work in these situations, and they may even cause irritation and additional health problems.

As a pest management professional, you should be aware that there are many potential causes of itching and irritation other than pests. Allergies, cosmetics, medications, and environmental contaminants all can produce reactions similar to insect bites. While this makes the experience no less real or unpleasant for the affected individual, it underscores the importance of keeping an open mind to the possibility of non-insect causes of such reactions. Much like a detective, you should attempt to rule out all potential sources of irritation through the process of elimination.

Sources of Irritation

Itches and real or perceived bites of unknown origin can usually be attributed to one of four general sources: (1) obscure biting arthropods (e.g., insects or mites), (2) personal use products, (3) environmental factors, or (4) health-related conditions. Specific agents most often implicated as irritants are summarized in Table 5-3 and discussed in detail below.

Obscure biting arthropods In some cases, insects or minute, biting mites prove to be the source of irritation. Although these pests are quite small, most are visible upon close examination. The location and appearance of bites or welts on the body is another key consideration in determining if pests are causing the irritation as well as which species is involved.

Fleas are the most common source of insect bites within homes. Although fleas are small (1/8") and fast-moving, they are large enough to be seen. They usually bite people around the ankles, producing a small, red, hardened and slightly raised welt. Fleas are most often associated with pets, although the presence of mice, rats, squirrels, skunks or raccoons can also result in fleas infesting a home.

Lice may also cause intense itching and irritation. Infestations occur on the head and other hairy areas of the body. Lice are tiny, grayish-white insects, but are visible under close inspection.

Mites are very tiny arthropods which occasionally infest structures and bite people. In most cases, the infestation can be traced to birds nesting in an attic or on a window ledge, etc., or to an infestation of mice or rats. When a bird or rodent dies or the young leave the nest, thousands of parasitic mites may migrate indoors and bite humans. Bird and rodent mites are smaller than fleas and lice, but if you look closely they will appear as tiny, dark specks that move.

There are two notable exceptions where mites may be the source of irritation but are too small to be seen with the naked eye. The human itch (scabies) mite burrows into the skin, causing intense itching and irritation. Skin between the fingers, the bend of the elbow or knee and the shoulder blades are areas most often affected. The intense itching is accompanied by a rash. Scabies is readily diagnosed and treated by most physicians.

Chiggers also bite people and generally are too small to be seen without magnification. Chiggers live outdoors in tall weeds and grass. They crawl onto people and move upward until they encounter a point of constriction between skin and clothing, such as around the ankles, behind the knee or at the waistline. Chigger bites produce a hardened, red welt which begins to itch intensely within 24-48 hours. Consequently, people may not associate the irritation with the fact that they were bitten while walking outdoors a day or two before. Delayed irritation following a "bug" bite is also common with such pests as mosquitoes and ticks, as well as with the contact dermatitis which results from exposure to poison ivy/poison oak.

Mosquitoes, ticks and a limited number of other arthropods may also bite people, but these pests are usually large enough to be seen at the time the irritation is felt. The vast majority of insects and related pests encountered in homes and buildings cannot bite people; yet, they are often blamed for itching or irritation caused by other factors.

If a person believes that insects too small to be seen are crawling over his or her skin, strips of clear cellophane tape may be patted over the affected area as the "crawling" sensation is occurring. Most small biting arthropods move slowly and will be picked up by the tape if present. Tape samples should be attached to a white index card and labeled to indicate from where they were collected.

Household products There are literally hundreds of non-insect agents capable of causing itching and irritation.

Obscure Biting Arthropods*	Household Products	Environmental Factors Physical irritants	Environmental Factors Chemical irritants	Health-Related Conditions
lice	soaps	paper	formaldehyde (from particle board)	pregnancy
fleas	cosmetics/hair products	fabric	wall and floor coverings	communicable diseases
chiggers	ammonia-based cleaners	insulation fibers	ammonia	stress
Biting midges/mosquitoes	medications	low humidity	solvents/resins associated with paint and adhesives	diabetes
ticks	printing inks	seasonal changes in temperature	tobacco smoke	liver or kidney disorders
bedbugs	clothing	static electricity	volatiles for asphalt and tar installation	food allergies
				insect phobias

Table 5-3. Principal causes of itches and bites of unknown origin. *Many of these pests are large enough to be seen without magnification. One should also consider the possibility of delayed irritation such as from bites obtained while outdoors.

Household products are involved far more often than are pests and may cause skin reactions similar to insect bites. Products most often implicated include phosphate detergents, soaps, cosmetics, ammonia-based cleaning agents, hair products, medications, printing inks (especially from multiform carbonless carbon paper), and certain types of clothing, particularly those containing fire retardants. If a connection can be made between irritation and exposure to one of these potential irritants, avoiding further exposure may correct the problem. A dermatologist can usually confirm that a product, rather than a pest, is causing the irritation.

Environmental factors When two or more individuals experience irritation in the absence of pests, the cause is likely to be environmental conditions or contaminants dispersed in the air. The irritant(s) may be either physical or chemical in nature.

Physical irritants — The most common physical irritants are tiny fragments of paper, fabric or insulation. When these fibers contact the skin, they can produce symptoms ranging from a "crawling sensation" to intense itching accompanied by a rash, welts or open sores. If fibers or fragments are involved, the irritation is usually generalized, occurring over exposed areas of the body such as arms, legs, neck and head.

Irritation produced by paper fragments is especially common in offices where large quantities of paper are processed daily. Continuous-feed paper from computers and multi-page forms generate large amounts of fragments, resulting in accumulations on desktops and other surfaces. Newly installed or badly worn synthetic carpet, drapes or upholstery also shed fibers that can irritate skin.

Other potential sources of irritation are insulation fibers released into the air by heating/cooling systems in need of repair and sound-deadening fibers embedded into drop-ceiling tiles. These latter sources are especially suspect if there have been problems with the air-handling system or recent repair work on the ceiling.

Irritation is aggravated by static electricity, which increases the attraction of the tiny charged fibers to exposed skin. Low humidity, electronic equipment and nylon (e.g., from carpeting, upholstery or women's stockings) all increase levels of static electricity and the potential for problems from fragments or fibers. Static electricity may also cause body hair to move, giving the impression of insects crawling over the skin.

If fibers or fragments are suspected of causing the reactions, floors, rugs, work surfaces and furniture should be thoroughly and routinely vacuumed, and desktops and tables wiped down with a damp cloth. Static-reducing measures should also be considered, such as raising the humidity level of the air and installing static-resistant mats and pads under chairs and electronic equipment in offices. Anti-static sprays can be used to treat seat cushions and nylon stockings.

Dry air alone can cause irritation, producing a condition known as "winter itch." As skin loses moisture, itching results. A similar reaction can occur from changes in temperature; these tend to make skin more sensitive. A skin moisturizer is often helpful in these situations.

Airborne chemical irritants — Indoor air pollution can be a serious problem in modern office buildings and other energy-efficient structures where air is recirculated over and over. Indoor air pollution can also be a problem in homes. As the concentration of chemical contaminants in the air increases, people may experience dizziness; headaches; and eye, nose or throat irritation. Certain air-borne contaminants can also produce rashes and skin irritation similar to insect bites. Chemical contaminants most often responsible for these reactions include ammonia-based cleaning agents; formaldehyde emitted from wall and floor coverings; tobacco

smoke; and solvents and resins contained in paints, glues; and adhesives.

Reactions to airborne chemicals most often occur in buildings with inadequate ventilation, especially those that are new or have been refurbished with new paint or wall or floor coverings. If indoor air pollutants rather than insects are suspected, contact an industrial hygienist. These specialists are equipped to monitor ventilation levels and the presence of allergy-producing contaminants. Companies specializing in environmental health monitoring have listings in the telephone directories of most metropolitan areas.

Health-related conditions Health-related conditions may be responsible for irritation mistakenly attributed to insects. Itching and skin irritation are common during pregnancy (especially during the last trimester) and may also occur in conjunction with diabetes; liver, kidney and thyroid disease; and herpes zoster (shingles). Food allergies are another common cause of itching and irritation.

One's emotional state can likewise induce skin reactions that can be mistaken for insect bites. Stress and conflict at work or home can produce itching and irritation. The itching response can be induced in other individuals simply by the "power of suggestion"; i.e., when one person in a group feels an itch or bite and begins to talk about it, others also feel the urge to scratch as well (a condition known as Bell's syndrome).

Delusions of parasitosis is a more serious emotional disorder characterized by an irrational fear that living organisms are infesting a person's body. Cases of delusory parasitosis often have similar symptoms and patterns of behavior. Patients typically report "bugs" invading their ears, nose, eyes and other areas of their body. The "creatures" frequently disappear and reappear and change colors while being observed. Specimens brought in for identification usually consist of bits of dead skin, hair, lint and miscellaneous debris. The skin of the individual is often severely irritated from desperate scratching, excessive bathing and application of ointments. While these occurrences may seem bizarre to persons who are not affected, they are frighteningly real to the patient. Delusions of parasitosis as well as other suspected emotional or medical conditions should be brought to the attention of a dermatologist or other physician.

Finding a Solution

There is no easy way to pinpoint the cause of so-called "invisible" itches. The most important consideration in determining if pests are involved is whether or not anyone has actually seen or captured any "bugs" as the itching or irritation is occurring. As noted earlier, most insects and mites that bite humans can be seen without magnification if you look carefully. Pesticides should not be applied unless there is actual evidence that pests are the cause of irritation.

Most often, pests will not be involved and relief from irritation will lie outside the realm of pest control. Approaching these problems in a rational and methodical manner will increase the chances of finding other likely sources of irritation. Refer to the list of likely irritants and follow suggestions that were mentioned earlier for alleviating the condition.

Review Questions

1. Rocky Mountain spotted fever is transmitted by_____.
   - A. seed ticks
   - B. cat fleas
   - C. American dog ticks
   - D. brown dog ticks

2. Seed ticks or tick larvae have _____pairs of legs.
   - A. one
   - B. two
   - C. three
   - D. four

3. In Tennessee, cat fleas are a medical concern because they transmit _____.
   - A. dog tapeworm
   - B. Rocky Mountain spotted fever
   - C. Lyme Disease
   - D. La Crosse encephalitis

4. The food of the 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

5. Adult fleas obtain blood by _____.
   - A. sucking
   - B. chewing
   - C. absorbing
   - D. lapping

6. Vacuuming areas frequented by pets increases flea control by _____.
   - A. removing 60 percent of the eggs & 27 percent of the larvae
   - B. stimulating adults to emerge from the cocoon
   - C. straightening carpet fibers
   - D. all of the above

7. Steps for a complete flea control program listed in order are _____.
   - A. treat pet, vacuum, treat indoors and outdoors
   - B. spray indoors and outdoors, dip pet and vacuum.
   - C. spray pet and vacuum on day one, treat indoors and outdoors on day two
   - D. vacuum and treat indoors and outdoors on day one, treat pet on day two

8. Application of an IGR will _____.
   - A. kill adults
   - B. immunize the pet
   - C. prevent immatures form reaching the adult stage
   - D. breakdown fecal blood

9. Ultrasonic devices are ineffective in managing flea populations.
   A. True
   B. False

10. Lyme disease is transmitted by _____, which is rarely found in Tennessee.
   A. Dermacentor variabilis
   B. Amblyomma americanum
   C. Rhipicephalus sanguineus
   D. Ixodes scapularis

11. The only effective way to remove a tick attacked to a person is with _____.
   A. nail polish
   B. alcohol
   C. a pair of tweezers
   D. lighted cigarette

12. A nonchemical method for reducing tick problems include:
   A. mowing the lawn
   B. sealing cracks in chain link fences
   C. walking many times over the lawn
   D. building tick "houses" away from the structure

13. _____ ticks attack dogs but rarely humans.
   A. American dog
   B. Lone star
   C. Brown dog
   D. Golden dog

14. Rodent and bird mites are usually about _____.
   A. the size of a period at the end of a sentence.
   B. 1/10 the size of the host
   C. 1/4 the size of the host
   D. the size of a Varroa mite

15. Chiggers burrow into the skin.
   A. True
   B. False

16 The preferred host of the common bed bug is _____.
   A. humans
   B. bats
   C. bugs
   D. birds

17. Paper wasps construct nest shaped like a (or an) _____.
   A star
   B. sheet of paper
   C. football
   D. umbrella

18. Bald-faced hornets nests may resemble a (or an) _____.
   A. star
   B. sheet of paper
   C. football
   D. umbrella

19. The best season and time to treat yellowjacket nests are
   A. late summer, mid-morning
   B. late summer, night
   C. spring, mid-morning
   D. spring, night

20. European hornets are attracted to lights and may be found tapping at windows at night.
   A. True
   B. False

21. Black widow spider venom is a _____.
   A. cell toxin
   B. respiratory toxin
   C. renal toxin
   D. nerve toxin

22. Brown recluse spiders have _____.
   A. four pairs of eyes in a semi-circular arrangement and a red hour glass marking
   B. three pairs of eyes in a semi-circular arrangement and a red hour glass marking
   C. three pairs of eyes in a semi-circular arrangement and a brown violin marking
   D. four pairs of eyes in a semi-circular arrangement and a brown violin marking

23. Glue boards are effective at catching mice and cockroaches, but are ineffective in trapping brown recluse spiders.
   A. True
   B. False

Answers: 1. C, 2. C, 3. A, 4. B, 5. A, 6. D, 7. A, 8. C, 9. A, 10. D, 11. C, 12. A, 13. C, 14. A, 15. B, 16. A, 17. D, 18. C, 19. D, 20. A, 21. D, 22. C, 23. B.

Chapter 6 Fabric Pests

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

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

Carpet Beetles

Carpet beetles feed on animal and plant substances such as wool, fur, feathers, hair, hides, horns, silk and bone, as well as cereals, cake mixes, red pepper, rye meal and flour. Other substances include powdered milk, dog and cat food, leather, book bindings, dead insects, cotton, and linen and rayon when stained with spilled food or animal excreta. The larvae cause the damage. They crawl from room to room and live behind baseboards, molding, in heating system air ducts, dresser drawers, carpets, clothing and furniture. Adult beetles fly readily and may feed outdoors on flower pollen.

There are four species of carpet beetles most often encountered: black carpet beetle, *Attagenus megatoma*; varied carpet beetle, *Anthrenus verbasci*; common carpet beetle, *Anthrenus scrophulariae*; and furniture carpet beetle, *Anthrenus flavipes*.

Identification

Adult black carpet beetles (Figure 6-1) are oval and shiny black with brownish legs. They vary in length from 1/8 to 3/16 inch. Larvae (Figure 6-2) are golden to dark brown and are about 1/2 inch long, with the body resembling an elongated carrot or cigar with a long brush of bristles at the tail end.

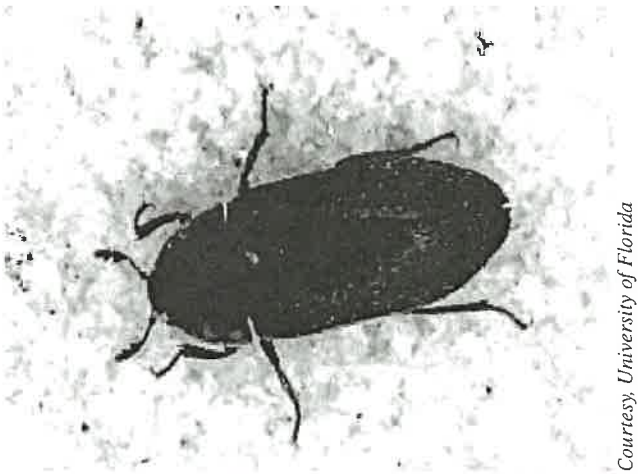
Adult varied carpet beetles are about 1/10 to 1/8 inch long and are nearly round. The top body surface is usually gray with a mixture of white, brown and yellow scales and irregular black crossbands (Figure 6-3). The bottom surface has long, gray-yellow scales. Larvae (Figure 6-4) are about 1/4 inch long and are light to dark brown. The body is wide and broader at the rear than the front.

Adult common carpet beetles are about 1/10 to 1/8 inch long, nearly round and gray to black. They have minute, whitish scales and a band of orange-red scales down the middle of the back and around the eyes. Larvae are elongated, oval, reddish-brown, about 1/4 inch long and covered with many brownish-black hairs.

Adult furniture carpet beetles (Figure 6-5) are about 1/16 to 1/8 inch long, nearly round and whitish, checkered with black spots, each outlined with yellowish-orange scales. The bottom surface of the body is white and the legs have yellow scales. Larvae are about 1/4 inch, elongated, oval and covered thickly with brownish hair.

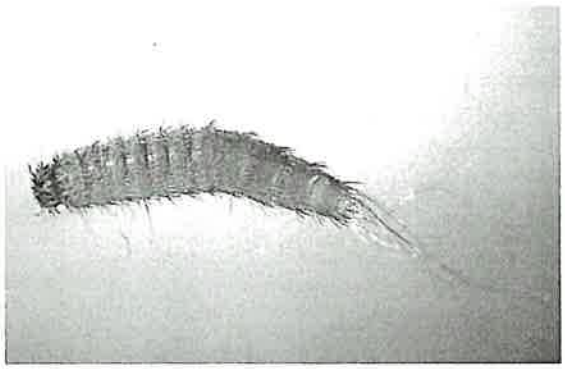
Life Cycle and Habits

All carpet beetles pass through the egg, larvae, pupa and adult stages. Adults fly readily and during warm, sunny days feed outdoors on the flower pollen. Depending on the species, each female can lay up to 100 or more white eggs, which hatch



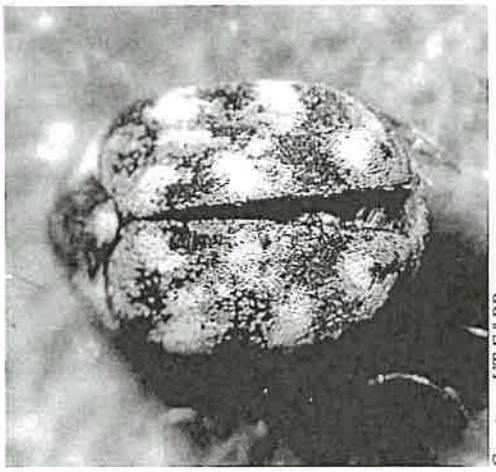
Courtesy, University of Florida

Figure 6-1. Black carpet adult.



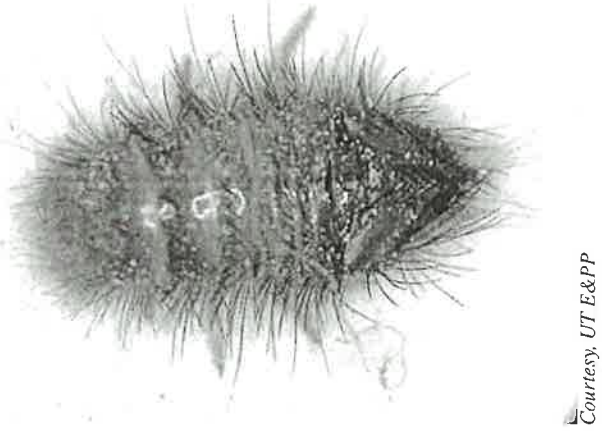
Courtesy, UT E&PP

Figure 6-2. Black carpet beetle larva.



Courtesy, UT E&PP

Figure 6-3. Varied carpet beetle adult



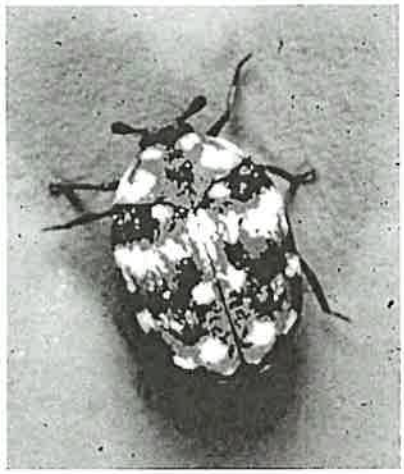
Courtesy, UT E&PP

Figure 6-4. Varied carpet beetle larva.

in eight to 15 days. Eggs laid indoors occur in lint accumulations near the food source, in air ducts, under heavy furniture, underneath baseboards, etc. After hatching, larvae begin their destructive feeding, avoiding light and molting several times as they develop. Depending on food and temperature, the larvae may spend 60 days to a year feeding. Their life cycle is shorter in warm rooms than in an unheated portion of the house during the winter. In the spring, the pupae develop into new adults. Usually there are three to four generations per year, except for the black or varied carpet beetle, which may only have one generation per year.

Control Measures

Inspections Locate the source of the infestation before treatment. If possible, remove the source of infestation, place it in a sealable plastic bag and discard it in an outdoor garbage pail. Carpet beetle larvae prefer to feed in dark, protected places. Use a flashlight and nail file to check lint under baseboards, in and under upholstered furniture, air ducts, stuffed animals, stored cereals, bird nests under eaves, wasp nests in attics, woolens, clothes closets, furs, etc. Cast skins, which are shed during molting, may be more abundant than larvae. Adult beetles flying around windows may help in locating the infestations. To help prevent carpet beetles from establishing themselves in homes, remove adult carpet beetles from flowers before the flowers are brought indoors.



Courtesy, University of Florida

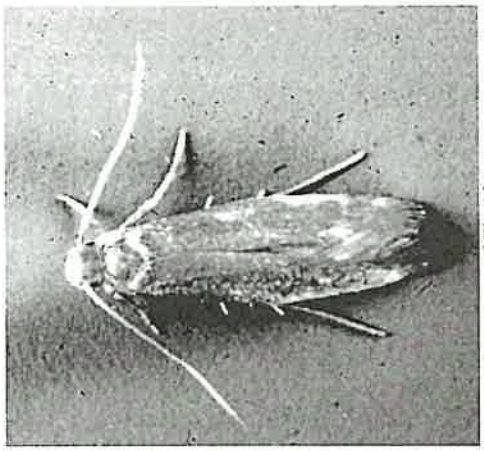
Figure 6-5. Furniture carpet beetle adult.

Prevention Good housekeeping is critical. Use a strong suction vacuum cleaner with proper attachments. Periodically brush, air outside or dry-clean furs, woolens, blankets, etc. Keep rugs, carpets, draperies, furniture, baseboards, air vents, molding and other hard-to-reach places clean. Destroy untreated, worthless animal skins, valueless insect collections, old woolen rags and old clothing. Cedar-lined closets and chests are not 100 percent effective in controlling these pests. Clients may use napthalene flakes or balls with garments in sealed containers. Be sure that all cloth goods are dry-cleaned, washed, pressed with a hot iron, sunned or brushed prior to storage. Fur storage in cold vaults may prevent larvae from feeding. Mothproofing when woolens are manufactured may provide long-term effectiveness, whereas treatments at dry cleaners are less permanent and need to be renewed regularly.

Insecticides After thoroughly cleaning under heavy furniture, rugs, rug pads and carpets, especially around the edges, spray under these items with insecticides, but heed the warning about insecticides staining carpet! Spraying other areas where insects crawl or hide, such as in cracks and crevices, may also be effective. Before using insecticides, read the label and follow directions. Upholstered furniture and pillows may require fumigation by a pest control operator because surface sprays would not be effective. Alternative methods of fumigating using nontoxic gases are currently being explored. Fumigation requires a fumigation (FUM) license.

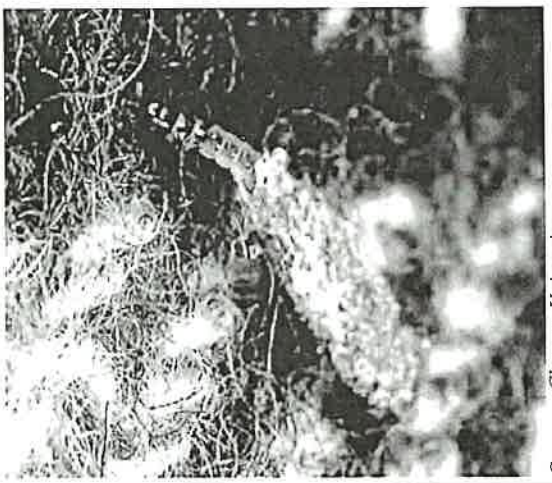
Clothes Moths

Clothes moth larvae feed on wool, feathers, fur, hair, leather, lint, dust and paper and occasionally cotton, linen, silk and synthetic fibers. They are especially damaging to fabric stained with beverages, urine and oil from hair and sweat. Most damage is done to articles left undisturbed for a long time, such as carpets under heavy furniture and clothing in storage. Three clothes moths encountered in Tennessee are the following: webbing clothes moth, *Tineola bisselliella;*



Courtesy, University of Florida

Figure 6-6. Webbing clothes moths are buff colored and hairs on head are upright and reddish gold.



Courtesy, Clemson University

Figure 6-7. The larva of the casemaking clothes moth spins small silken case around itself.

casemaking clothes moth, *Tinea pellionella*; and carpet or tapestry moth, *Trichophaga tapetzella*.

Identification

Adult webbing clothes moths (Figure 6-6) have a wingspread of about 1/2 inch. The buff-colored moth with a satiny sheen is about 1/4 inch long with wings folded. Hairs on the head are upright and reddish-gold. Eggs are oval, ivory and about 1/24 inch long. Larvae are shiny, creamy white with a brown head, are up to 1/2 inch long, spin long threads and construct tunnels of silk.

Adult casemaking clothes moths have a 1/2-inch wingspread. Forewings are yellowish-brown, and there are three distinct, dark dots on each wing. Hind wings are smaller, lighter and fringed with hair and scales. Eggs are whitish and larvae are opaque-white with brown heads. The larva spins a small silken case around itself and carries it while feeding (Figure 6-7).

Adult carpet or tapestry moths are larger than webbing or casemaking clothes moths at 1/3 to 5/12 inch long with a 3/4 inch wingspread. Adults have white heads, with the first third of the front wings black and the lower two-thirds creamy white. Hind wings are pale gray. Larvae are small, creamy white caterpillars with dark heads.

Life Cycle and Habits

Clothes moths rarely fly to light at night and instead prefer darkness. Any clothes moths fluttering around the house are probably males, as females travel by either running or hopping, especially webbing clothes moth females. Female webbing clothes moths lay from 40 to 50 eggs that hatch in four to 21 days. Larvae prefer to feed on soiled material, spinning silken mats or tunnels and incorporating textile fragments and bits of feces into the construction. The pupal case is silk with bits of fiber and excrement attached to the outside. The life cycle is about 65 to 90 days.

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

Adult carpet or tapestry moths are rarely found. Females lay 60 to 100 eggs in a lifetime, and the larva develops in about three months as it builds silken tubes or burrows through infested materials such as hair-stuffed furniture, tapestries, old carpets, furs and feathers.

Control Measures

Inspection Locate the source of infestation before treatment. Larvae prefer to feed in secluded, dark places. Use a flashlight and nail file to check for woolen lint and hair under baseboards, in and under seldom moved upholstered furniture, in air ducts, in carpets at the corners of the room and along edges, in stored clothing and in other places not readily accessible. Adult moths do not feed in fabrics, but may be seen in darkened corners at night.

Prevention Good housekeeping is critical in preventing or controlling clothes moth damage and the following should be recommended to clients. Regularly use a strong suction vacuum cleaner with proper attachments to remove lint, hair and dust from floor cracks, baseboards, air ducts and carpets as necessary. Keep closets and dresser drawers clean. Regularly clean rugs where they fit close to the baseboards and under the quarter round. Launder and dry-clean clothes and other items before storage. Egg-laying clothes moths are attracted to soiled articles. Sunlight and wind reduce the number of larvae and damage. Sun, brush and expose clothing to the weather. Frequent use of woolens and other animal fiber clothing almost assures no damage from clothes moth larvae.

Typically, cedar-lined closets do not seal sufficiently to retain cedar oil and are not very effective in controlling clothes moths. Cedar chests may be slightly more effective because they seal better; but, the oil of cedar still evaporates. Any box or bag that is tight and can be sealed is a good storage container. Place garments in containers and add naphthalene flakes interspersed between sheets of paper. Be sure that all

cloth goods are dry-cleaned, washed, pressed with a hot iron, sunned or brushed prior to storage. Fur storage in cold vaults is effective. Mothproofing when woolens are manufactured may provide long-term effectiveness, whereas treatments at dry-cleaners are less permanent and need to be renewed regularly.

Insecticides After thoroughly cleaning rugs, rug pads, under heavy furniture and carpets, especially around the edges, spray surfaces where insects crawl or hide. Apply sprays to edges of wall-to-wall carpeting in closets, corners, cracks, baseboards, molding and other hiding places. Exercise caution to prevent carpet discoloration following the use of insecticides on carpets. The dyes used in the manufacturing of carpets have changed which may create a problem in the use of insecticides on carpets. Before using insecticides, read the label and follow directions. Alternative methods of control, such as removing oxygen from a closed container to kill insects, are being explored. See the pesticide label for further precautions pertaining to pesticide use.

Upholstered furniture and pillows may require fumigation by a pest control operator, as surface sprays would not be effective. A 6x dosage of sulfuryl fluoride is needed and a second fumigation suggested after egg hatch. Fumigation requires a license in fumigation (FUM).

Review Questions

1. One of the first steps in a pest management program for fabric pests would be _____.
   A. removing the source of infestation
   B. spraying infested sources
   C. insecticidal dusting of edges
   D. fumigating

2. Two groups of insects feed on stored woolens, furs and feathers. They are _____.
   A. clothes moths and carpet beetles
   B. carpet moths and blanket beetles
   C. blanket beetles and clothes moths
   D. clothes moths and tapestry moths

3. Carpet beetle adults are only found in structures.
   A. true
   B. false

4. Black carpet beetle larvae are _____.
   A. oval with scales at the tail end
   B. carrot-shaped with scales at the tail end
   C. oval with a long brush of bristles at the tail end
   D. carrot-shaped with a long brush of bristles at the tail end

5. Varied carpet beetle larvae are _____.
   A. carrot-shaped
   B. oval
   C. cigar-shaped
   D. broader at the rear than the front

6. Carpet beetle larvae are attracted to light and are often found feeding on flower pollen.
   A. true
   B. false

7. _____ moth larvae prefer to feed on soiled material, spinning silken mats over it.
   A. Common clothes
   B. Webbing clothes
   C. Carpet or tapestry
   D. Casemaking clothes

8. _____ moth larvae do NOT spin a web of silk over the food material, but eat clean-cut holes, not usually in one spot.
   A. Common clothes
   B. Webbing clothes
   C. Carpet or tapestry
   D. Casemaking clothes

9. Black carpet beetle adults have a _____.
   A. gray body with a mixture of white, brown and yellow scales
   B. gray to black body with white scales and a band of orange-red scales down the middle of back and around eyes
   C. whitish body, checkered with black spots each outlined with yellowish-orange scales
   D. shiny black body

10. Clothes moths are attracted to lights and therefore are often confused with Indian meal moths.
   A. true
   B. false

11. _____ moths are the most commonly encountered clothes moth in Tennessee.
   A. Common clothes
   B. Webbing clothes
   C. Carpet or tapestry
   D. Casemaking clothes

12. _____ moths are the rarely encountered in Tennessee.
   A. Common clothes
   B. Webbing clothes
   C. Carpet or tapestry
   D. Casemaking clothes

Answers: 1. A, 2. A, 3. B, 4. D, 5. D, 6. B, 7. B, 8. D, 9. D, 10. B, 11. B, 12. C.

Chapter 7 Stored Product Pests

Many species of pests infest and damage stored cereals, grains, nuts, dried fruit and other food products. These include birds, rodents, fungi and other microorganisms, mites and certain insects such as weevils, beetles, moths, silverfish and firebrats. Stored product pests are widespread and cause serious economic losses to grain producers, food processors and consumers. They attack stored products on farms and in processing plants, warehouses, grocery stores, restaurants, homes, and virtually any other location where food is stored or prepared.

Contamination of food products by pests or pest excrement cannot be tolerated, even at low levels. Contaminated food may contain disease-causing organisms or toxins that can cause human illness. Some types of pest infestations destroy or damage the food's nutritional value or change its physical properties. Even if the contaminated food remains healthful, it lacks aesthetic appeal. Some contaminated grains may require special cleaning and screening to remove the pest and its damage; nuts and dried fruit may need to be hand sorted. The added expense of these processes increases food-production costs.

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

Use pesticides as one management tool to stop the buildup of pests and to supplement other controls. Follow pesticide label directions carefully and be certain that application equipment is properly calibrated.

Stored Product Insects

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

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

Beetles

Sawtoothed Grain Beetle, *Oryzaephilus surinamensis*
Merchant Grain Beetle, *Oryzaephilus mercator*

The sawtoothed grain beetle and the merchant grain beetle are similar in appearance and easy to confuse (Figures 7-1, 7-2 and 7-3). The area behind the eye is smaller and more pointed in the merchant grain beetle as compared to the sawtooth grain beetle. Adults are about 1/10 inch long and reddish brown to dark brown. Lateral margins of the thorax contain six sawtoothed projections on each side. These are long, narrow beetles with characteristic flattened bodies, giving them access to small cracks and crevices. Both species have well-developed wings, but the sawtoothed grain beetle has not been seen flying. Adults of both species are usually seen running rapidly over stored food. Larvae have brown heads and their bodies are yellowish, elongated, and segmented, with three pairs of legs. They crawl actively during feeding.

Adult females lay between 45 and 285 eggs singly or in small batches in or around suitable larval food sources. Eggs hatch in about eight days. Larvae pass through two to four

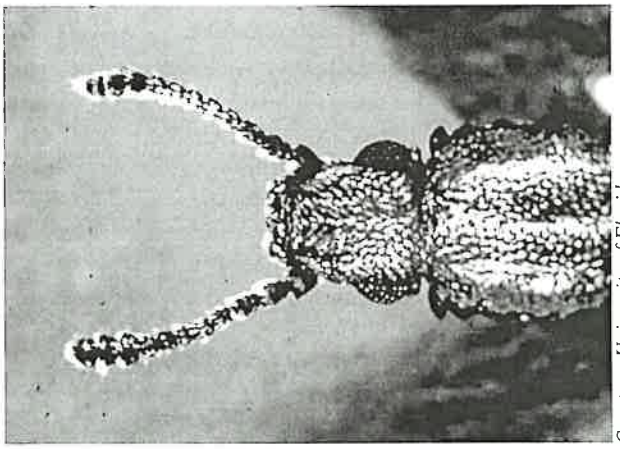
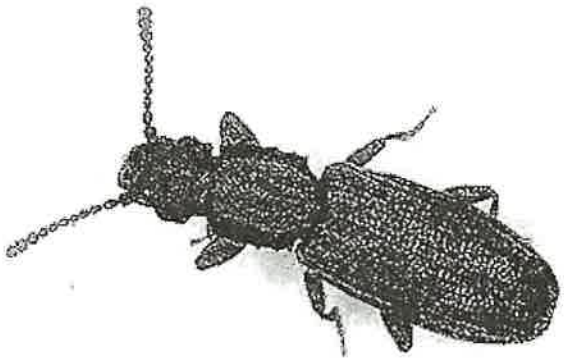
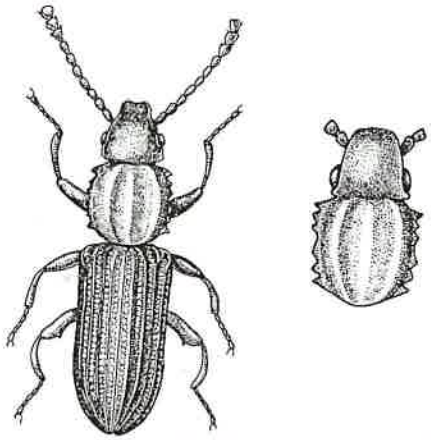

Courtesy, University of Florida

Figure 7-1. Merchant grain beetle.



Courtesy, University of Florida

Figure 7-2. Sawtoothed grain beetle.



Courtesy, University of Florida

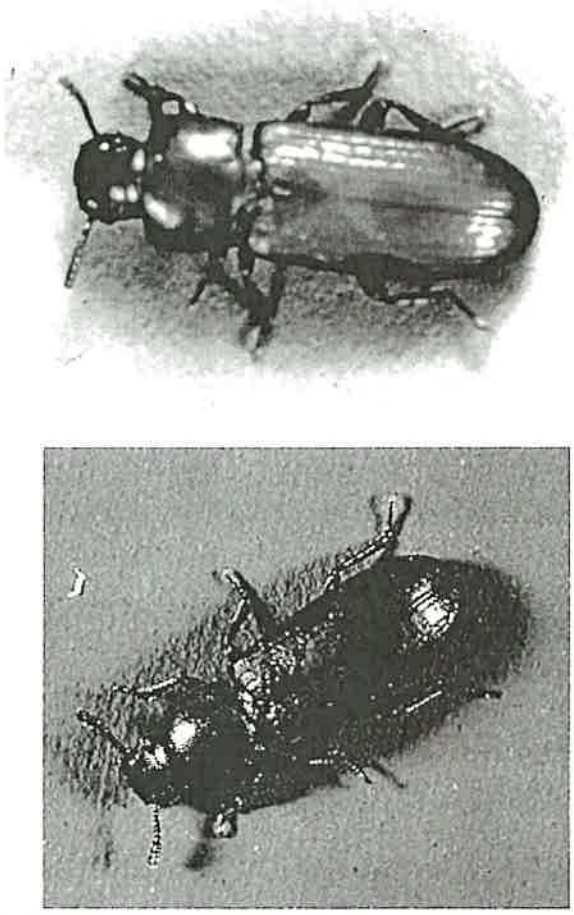
Figure 7-3. The area behind the eye is larger and less pointed in the sawtoothed grain beetle (left) than the merchant grain beetle (right).

instars over an average of 37 days, and pupation takes another six days. Temperature and humidity affect the development time and the number of larval instars.

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

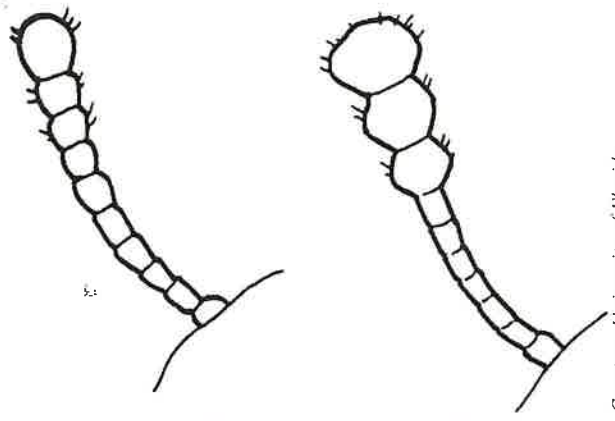
Confused Flour Beetle, *Tribolium confusum*
Red Flour Beetle, *Tribolium castaneum*

The confused flour beetle and the red flour beetle are the most common and serious pests of flour, cereal and broken grain (Figure 7-4). They are closely related, similar in appearance and often occur together. Flour beetles are members of the large coleopteran family Tenebrionidae, commonly known as the darkling beetles. They emit a foul-smelling, gaseous secretion when disturbed. Adults are about 3/16 of an inch long, flattened and shiny reddish brown. Antennae of the confused flour beetle terminate in four segments that gradually enlarge to form a club-like shape, whereas antennae of the red flour beetle abruptly terminate in three larger, club-like segments (Figure 7-5).



Courtesy, Credit USDA-ARS-GMPRC

Figure 7-4. Confused flour beetle (top) and red flour beetle.



Courtesy, University of Florida

Figure 7-5. Antennae of the confused flour beetle terminate in four segments that gradually enlarge to form a clublike shape. Antennae of the red flour beetle abruptly terminate in three larger, clublike segments.

Adult flour beetles live up to two years. Females produce 400 to 500 eggs in their lifetime, laying two or three per day; eggs hatch in five to 12 days. Larvae pass through five to 18 instars, typically seven or eight, over a period ranging from one to four months. Larvae are slender and wirelike, whitish colored with yellow tinges. They are distinguished from

Figure 7-7. Rice (top) and Granary weevil.

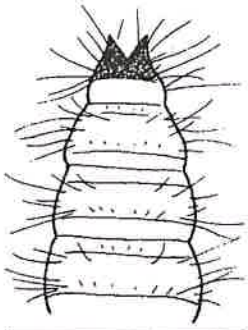


Figure 7-6. Larvae of flour beetles have a prominent, two-pointed termination of the last body segment.

other stored-product insect larvae by the prominent, two-pointed termination of the last body segment (Figure 7-6).

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

Granary Weevil, *Sitophilus granarius*
Rice Weevil, *Sitophilus oryzae*

Weevils are distinguished from other beetles by the slender elongation of their heads, a feature responsible for the common name of snout beetles. Granary and rice weevils (Figure 7-7) are serious grain pests.

Several features distinguish the granary weevil from the rice weevil. The granary weevil is about 1/8 inch long and

Figure 7-8. Cowpea weevil.

shiny dark brown or black. The top central area of its thorax is covered with elongated depressions or punctures. Adults have nonfunctional, vestigial wings. By contrast, the rice weevil is a good flyer and is slightly smaller. It is reddish brown to black, and usually has four reddish or yellowish spots on its wing covers. The top-central area of the thorax of the rice weevil is covered with round punctures.

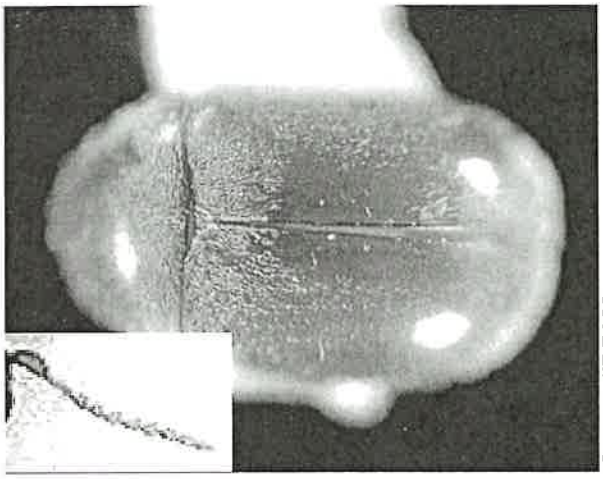
Both species bore holes into grain kernels to deposit their eggs. Larvae feed and pupate inside kernels and also feed on caked flour and tightly compressed cereals. Granary weevils have become adapted to living entirely in stored grains and never forage in the wild for food, hence their lack of wings.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

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

Bean Weevil, *Acanthoscelides obtectus*
Cowpea Weevil, *Callosobruchus maculatus*

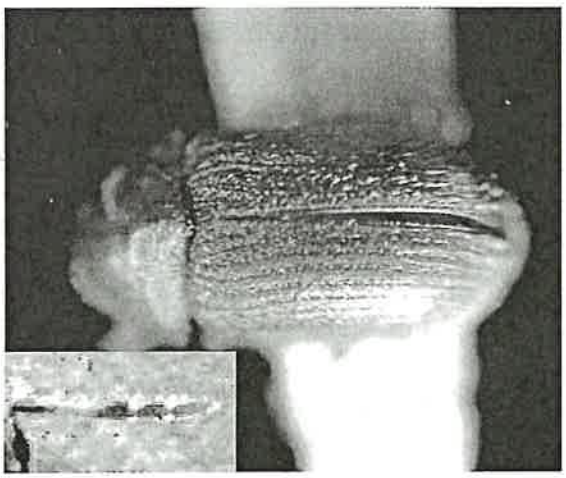
Bean weevils and cowpea weevils (Figure 7-8) are not weevils but belong to the seed beetle family Bruchidae. Larvae bore into seeds where they feed and pupate. After pupation, adults bore an emergence hole in the seed. Often more than one larva infest a single seed. Bean weevils are about 1/2 inch long and are light olive brown with darker brown and gray markings and reddish legs. Eggs are laid on pods of legumes such as beans, peas and lentils in the field or on the surface of stored legumes. Grains, cereals and other stored food products are not infested by bean weevils. Infestation of stored legumes can easily occur from harvested products being brought in from the field.

Females lay about 75 eggs during their lifetime; these are deposited singly on or near host seeds and hatch after five to 20 days. Larvae feed for four to six weeks before pupating. Adults hibernate during the winter, but if temperatures rise, they emerge and females begin egg laying again.



Courtesy, UT E&PP

Figure 7-9. Cigarette beetle adult with saw-like antennae (insert).



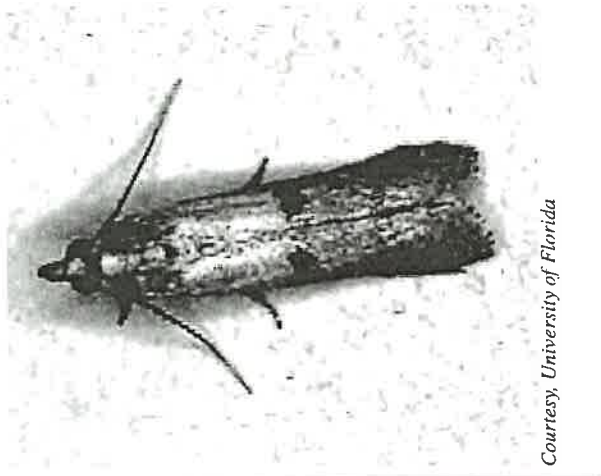
Courtesy, UT E&PP

Figure 7-10. Drugstore beetle with three-segmented antennal club (insert).

Cigarette Beetle, *Lasioderma serricorne*
Drugstore Beetle, *Stegobium paniceum*

Cigarette and drugstore beetles (Figure 7-9 and 7-10) are members of the Anobiidae family, which also includes deathwatch or powderpost beetles. Adults can be distinguished by their humped appearance due to their downward-bent head and prothorax. The cigarette beetle is reddish yellow to brownish red. Adults are about 1/8 inch long and have the distinctive humped appearance characteristic of this group. Females produce about 30 eggs over a three-week period; these usually hatch within one week. Eggs are attached to sources of stored food such as tobacco, rice, raisins, grains, pepper and many other stored products. Larvae are curved, plump and hairy; they are yellowish with a light brown head. The larval stage lasts from five to 10 weeks and three to six broods are produced in a year.

Adults of the drugstore beetle are almost the same size as the cigarette beetle. They are reddish brown and can be distinguished from the latter by the longitudinal striations, or ridges, on their elytra. They are also less humped. Cigarette beetles have saw-like antennae, whereas the drugstore beetle antennae have a three-segmented club.



Courtesy, University of Florida

Figure 7-11. Indian meal moth adult.

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

Black Carpet Beetle, *Attagenus megatoma*

The black carpet beetle is described in the previous chapter as a fabric pest. This insect is widespread and feeds on a large variety of dried foods including beans, peas, corn, wheat, rice and many types of seeds.

Moths

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

Indian meal moth, *Plodia interpunctella*

The Indian meal moth (Figure 7-11) is the most common pest of coarsely ground flours (such as whole wheat flour) and cornmeal. It is widespread in grocery stores, warehouses and kitchens. The Indian meal moth also infests shelled or ear corn, broken grains, dried fruit, seeds, peas and beans, crackers, biscuits, nuts, powdered milk, chocolate, candy, red peppers, dry dog food and other commodities. Unlike weevils and other beetle larvae, Indian meal moths spin large amounts of webbing, further contaminating food products.

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

Egg laying usually begins in April. Females lay eggs at night, either in masses or singly, and produce 200 to 400 eggs. Larvae are a dirty-white color but may take on different hues depending on the food ingested. The larva's head and prothoracic shield are brown. Pupation takes place in a silken cocoon. The larval period varies greatly between one and 10 months, depending on environmental conditions and

available food. The normal complete life cycle of this pest takes about six to eight weeks.

Management Guidelines for Stored Product Insects

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

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

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

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

Inspection and detection Inspection and detection are necessary parts of a stored product pest management program. They provide information, evaluate control methods used and monitor for reinfestation.

Make a complete and thorough inspection of the premises to locate potential infestation sources. Carefully examine stored food such as grains, dried fruit, flour, dog food and seeds. Check around buildings because some stored product insects are attracted to certain flowers and shrubs, and outdoor lighting.

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

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

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

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

Check traps regularly — daily if there is a low tolerance to stored product insects on the commodity or weekly under normal conditions. At each inspection, record the number of pest insects caught and remove them from the traps. Replace pheromones according to manufacturer's instructions. Change sticky parts of the traps whenever they are coated with debris.

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

For stored bulk grains, use pheromones with specially designed probes positioned at different levels inside storage bins. Check probes periodically for insect pests and use catch data to find areas of infestation. This monitoring should also be used to evaluate the effectiveness of other control measures.

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

Keep insects out of buildings by using screens over doors and windows. Close off all other openings with wire screening or caulking. If it is not possible to exclude pests from the entire building, at least make sure the storage area is protected.

Locate and close rodent holes, as stored product insects can enter through these. If rodent baits are in the area, check them for infestation; even stored or unused bait may harbor insects. To keep from attracting insects into buildings, locate outdoor lighting away from doorways. Use sodium-vapor lights rather than mercury-vapor lights for outdoor lighting around warehouses and grocery stores, because insects are less attracted to yellow light.

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

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

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

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

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

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

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

Fumigants are used to control stored-product insects in bulk containers, truck trailers, railroad cars, warehouses and large storage areas. Fumigants are effective because they penetrate areas where pests occur or might become problems. To be effective, fumigation must take place in a well-sealed area so the concentration can build up to high enough levels; other conditions must also be met and specific problems overcome before fumigation. Small quantities of cereals and similar products can be fumigated in containers such as plastic pails or glass jars using dry ice (frozen carbon dioxide); however, if containers are tightly closed immediately after treatment, a vacuum will form that may cause them to implode. Tighten down the lid after the container warms to room temperature. Professionals need to be licensed in fumigation (or under the direct supervision of a licensed operator) before applying fumigants.

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

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

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

Mites

Mites occasionally infest stored food. They are known to feed on cheese, flour, grains, dried fruits, dried meats, cereal foods, dog and cat food, and animal feeds. Grains

often must first be damaged by insects or fungi before certain mite species invade. There are more than 112 species of mites commonly associated with stored foods. Because mites are extremely small, their presence goes unnoticed, but the damage they cause is sometimes very serious. Infested items become contaminated with dying and dead mites, cast skins and fecal materials.

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

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

Management Guidelines for Stored Product Mites

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

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

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

Review Questions

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. sawtoothed and merchant grain beetles

2. Psocids and grain mites need _____ to build large populations.
   - A. grains
   - B. processed meal
   - C. high protein
   - D. high humidity

3. Merchant grain beetles' area behind the head is _____ _____ than the sawtooth grain beetle.
   - A. larger and more pointed
   - B. smaller and more pointed
   - C. larger and more blunt
   - D. smaller and more blunt

4. Granary weevils can't fly, but rice weevils can. Rice weevils have _____.
   - A. 4 reddish spots on the head
   - B. 4 reddish spots on the elytra
   - C. 2 reddish spots on the head
   - D. 2 reddish spots on the elytra

5. Granary weevils never forage in the wild for food.
   - A. True
   - B. False

6. Which is not an example(s) of an anobiid beetle?
   - A. cigarette beetle
   - B. drugstore beetle
   - C. Powderpost beetle
   - D. red flour beetle

7. The most common pest of coarsely ground flours and cornmeal is a(n) _____.
   - A. black carpet beetle
   - B. Indian meal moth
   - C. cigarette beetle
   - D. drugstore beetle

8. Flour beetle larvae are distinguished from other stored product pest larvae by their _____.
   - A. webbing contaminents
   - B. two-pointed termination of the last body segment
   - C. elongated heads
   - D. hairy, almost fuzzy appearance

9. The bean weevil, *Acanthoscelides obtectus*, has a slender elongation of the head.
   - A. True
   - B. False

Answers: 1. A, 2. D, 3. B, 4. B, 5. A, 6. D, 7. B, 8. B, 9. B

Chapter 8 Occasional Invaders

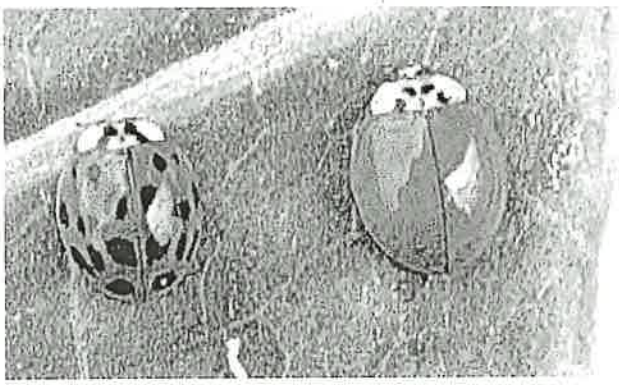
Occasional invaders are pests that do not usually live and breed inside a house, but can wander or migrate seasonally into structures. Some of these pests are associated with trees, shrubs, mulch or other habitats conducive to pest development. Others are attracted to lights at night. Some are dislodged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

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

Multicolored Asian Lady Beetle

In Tennessee, the invasion often starts around the third week in October. Multicolored Asian lady beetles (Figure 8-1), orange-red beetles with a variable number of spots, invade homes in the search of a protected overwintering spot. These beetles may congregate on the sunny sides of buildings by the thousands and if given the opportunity, will move inside. In Japan, they seek protected sites such as cracks and crevices in rocks on mountains. In the U.S., they use buildings as overwintering sites. This can be a particular problem in log homes because of the many cracks and crevices present.

Multicolored Asian lady beetles were first introduced into the U.S. to control aphids and therefore are considered a beneficial insect. They are distinguished from other lady beetles by black spots that form an "m" or "w" on the pronotum (area behind the head) and the square-shaped spots ranging in number from none to 19. Initially, these beetles were released for pecan aphid control, but they will also feed on rose, apple, poplar, conifer and crepe myrtle aphids.



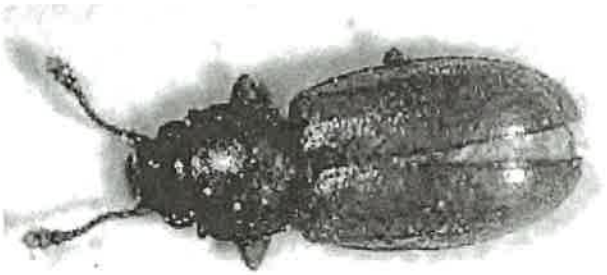
Courtesy, University of Kentucky

Figure 8-1. The Asian Multicolored lady beetle invades homes in search of protected overwintering sites.

Multicolored Asian lady beetles are beneficial. These beetles do not sting, carry diseases or consume or excavate wood. However, they can stain wallpaper and upholstery when crushed. Reports indicate some individuals have an allergic response to these lady beetles. These beetles seem to be attracted to light-colored walls, but this is not always the case. Dark-colored buildings are still invaded. Large windows or other reflective surfaces may also attract them. Vertical contrast, such as dark shutters on a lighter colored home, is also attractive to these insects.

Exclusion practices should be performed by September. The first step to prevent entry into a home is to seal cracks and crevices where they may enter the structure. (Gaps 1/8 inch or more will allow entry into a home). This includes caulking around window frames, fitting all outside doors with door sweeps, adding rubber bottom seals to garage doors, and using foam weather-stripping under sliding glass doors. Utility openings into the structure, such as outdoor faucets, gas meters, dryer vents, wires, etc. should be sealed. Holes can be filled with caulking, cement, steel wool or copper mesh. An easy way to seal openings around pipes is to stuff steel wool or copper mesh into the opening and seal with expandable foam. Caulk should be applied around cracks in window framing, siding, and other areas. Damaged window screens should be repaired. Insect screening may need to be installed behind attic and crawl space vents. Areas where the beetles have been seen congregating on the outside of homes should be cleaned with a mild detergent to remove any aggregation pheromone. If beetles still find a way into the home, place glue boards or pieces of tape near suspected beetle entry points. Once the entry point is located, it can be sealed. The beetles can be removed from the interior of the building using a vacuum and placed outdoors or killed.

Once the beetles have found a crack or crevice to overwinter, they may remain inactive on cool days. On warm days when the sun is shining, activity is often seen on the western or southern side of the house. Take notice of the direction from which the beetles are coming and try to locate their



Courtesy, UT E&PP

Figure 8-2. Foreign grain beetles are distinguished from similar beetles by the rounded lobes on the pronotum.

resting spot. On a cool day, locate this resting spot. They will be clustered and can easily be removed with a vacuum. Unfortunately, these resting spots may be in wall voids or other inaccessible spaces.

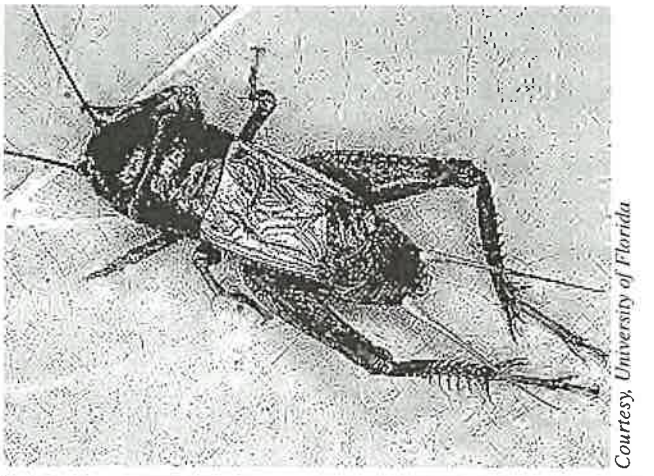
Traps have been developed to aid removal of lady beetles from buildings. Traps are most effective at night in the absence of competing light sources, but can be used during daytime if the room is completely dark and unlighted by windows or other light sources. Temperature in the room must be a minimum of 68 degrees, but the trap is most effective if the room temperature is 75 degrees Fahrenheit or higher.

If the site has experienced Asian lady beetle infestations in the past and if sealing the outdoor entry sites is impractical and light traps are considered too costly, apply fast-acting, residual insecticides such as cypermethrin, cyfluthrin, deltamethrin, lambda cyhalothrin, permethrin, or tralomethrin around possible entry points. This only works as a preventive treatment, it must be initiated before the beetles enter the structure (start the end of September) and it still may not be effective. These beetles usually fly the first or second day in the 60s (F) after a cold snap close to freezing.

Foreign Grain Beetles

Foreign grain beetles, *Ahasverus advena*, are small (1/12 inch), reddish-brown beetles that feed on molds and fungi. Contrary to their name, these beetles are not pantry pests (unless stored foods are moldy). Adult emergence may begin as early as the middle of July and continue through September. Foreign grain beetles look very similar to red or confused flour beetles, hairy fungus beetles or sawtoothed grain beetles, but can be distinguished from these species by the presence of a projecting rounded lobe on the front corners of the pronotum, the first segment behind the head (Figure 8-2). Because there are so many similar species, it is best to bring the suspect specimens to your county Extension agent. They will forward the specimen to the Plant and Pest Diagnostic Lab in Nashville.

Foreign grain beetles may appear in newly-constructed homes by the thousands. Typically, the female is attracted to poorly-seasoned lumber or wet plaster and wall board that supports fungal growth. Foreign grain beetles can also be associated with plumbing leaks, condensation problems or poor ventilation. Eggs are laid on these materials as the house is being built and larvae feed on the molds. In the late summer, adults become obvious when they emerge from the wall voids and are attracted to lights.



Courtesy, University of Florida

Figure 8-3. Field cricket.

Management To control these beetles, wet wood and the moisture source should be eliminated. Adding ventilation such as air conditioners or fans may be needed to remove the moisture. Often, homes will dry out naturally in 1-4 years, thereby eliminating the fungal food source and hence the beetles. Pyrethrin sprays can kill the adults, but need to be applied frequently, as the beetles continue to emerge from wall voids. Vacuum cleaners work just as well as sprays to remove any visible beetles that are present. An inspection with a moisture meter can locate the infected wall area or source of dampness. A residual aerosol or dust can then be injected into cracks and crevices along baseboards and into the wall voids. This may provide some relief; however, the beetles may still emerge from the baseboards and die on the floor.

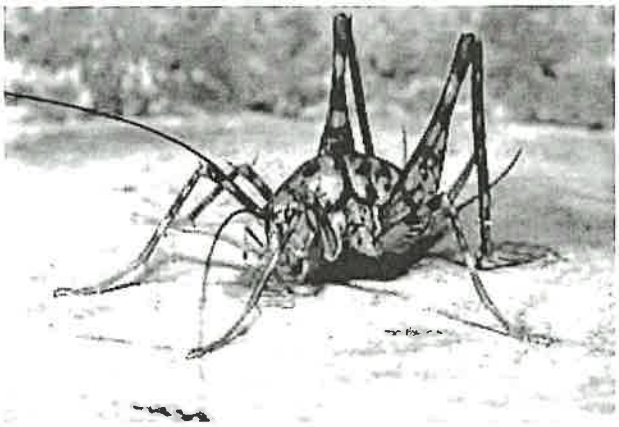
If the homeowner can tolerate the beetles during the period when they are most active (late summer) the problem may resolve itself. Remember, foreign grain beetles are a nuisance by their mere presence; they do not bite or damage wood, fabric or stored food in sound condition.

House and Field Crickets

Crickets are sometimes nuisances in buildings and they may also damage fabrics or other materials. They are especially destructive to silks and woolens. They are also attracted to perspiration and other stains on clothing and fabrics. Occasionally crickets invade a structure in large numbers. They are often attracted to lights around a building at night. Besides damage, they produce a chirping which may become annoying to building inhabitants.

Crickets belong to the insect order Orthoptera and are related to grasshoppers. These insects do not undergo a complete metamorphosis therefore, the young resemble adults except they do not have functional wings. Young and adults both have similar feeding habits.

Common crickets that invade buildings include the house cricket, *Acheta domesticus*, and the field cricket, *Gryllus* spp. (Figure 8-3), which are very similar in appearance, and camel crickets.



Courtesy, Clemson University

Figure 8-4. Camel cricket.

House cricket adults range in length between 1/2 and 3/4 inch. They may be light yellowish brown, with three dark bands on the head, or solid shiny black. This species has long, slender antennae. The field cricket is slightly larger, up to 1 inch in length, and usually brown or black. Females of both species have a long, thin ovipositor projecting from the tip of the abdomen.

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

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

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

Camel Crickets

Camel crickets get their name from their humpbacked appearance. These crickets are also called cave crickets because of their presence in this moist environment. Like all crickets, the camel crickets have very large hind legs and long antennae (Figure 8-4). They are brownish, wingless and can be slightly longer than one inch. Behaviors used to identify this cricket are their high jumping ability and upside down resting state. Also, no sound is produced by camel crickets.

Camel crickets are active at night and are attracted to cool, damp situations such as in wells, rotten logs, stumps and hollow trees, and under damp leaves, mulch, stones, railroad ties, boards, woodpiles and logs. Around homes they can be found in sheds, under concrete pads or air-conditioning units, in wells and other areas where moisture accumulates. Hot and dry weather may cause the crickets to move indoors in search of moisture. Indoors in Tennessee, they are commonly found in basements, crawlspaces, utility rooms and garages. Often they are so numerous that their feces will pile on the ground below them. Camel crickets are usually just a nuisance in buildings, but they have been documented to eat holes in lace curtains and clothes hung to dry.

Reproduction indoors is limited to situations that provide continuous dark, moist conditions. Overwintering may occur as a nymph or adult, depending on species. Eggs are laid in early spring and will usually hatch in April.

As with other crickets, sanitation and exclusion are very important in the control process. Installing vents and vapor barriers in the crawlspace should help keep this space well ventilated and dry. Wet crawlspaces may even require French drains. Crawlspace vents should be screened to prevent cricket entry. Reduce or eliminate moist harborage around the structure. Piles of wood, bricks, stones, boards, leaves, and other debris should be removed. Also, cracks and gaps in foundations, siding, or around windows and doors should be sealed. Pipe and conduit penetrations in the foundation should also be sealed. Glue boards can be placed near entry points to trap and detect crickets.

Insecticides should only be used if sanitation and exclusion practices do not accomplish control quickly enough. Indoor bait applications are limited to areas which are inaccessible to children or pets. Apply baits indoors to cracks and crevices, wall voids, unfinished attics and crawlspaces within buildings. Excess granules should be wiped up. Some baits can be scattered in unfinished attics and crawl spaces if the space is secure or inaccessible to children and pets.

Sprays, such as microencapsulated or wettable powder formulations, can be applied to entry points as an additional barrier. Dusts or sorptive powders can be blown into inaccessible areas. Vacuums are also effective in removing this pest. When large numbers of crickets are present in a crawlspace and are killed with insecticides, they should be removed to prevent the build up of carpet beetles and odors.

Silverfish and Firebrats

Silverfish and firebrats eat a wide variety of food, including glue, wallpaper paste, bookbindings, paper, starch in clothing, rayon fabric, wheat flour, cereals, dried meats and dead insects. Usually they are found trapped in a bathtub or sink.

Identification Silverfish have flat, elongated bodies 1/3 to 1/2 inch long and wider at the front end than the rear (Figure 8-5). These fragile, wingless insects are covered with scales and have two long, slender antennae on the head and three long, tail-like appendages on the rear. These three appendages, one directed backward and the other two curving outward, plus the two antennae, are nearly as long as the body. Sometimes these insects are known as bristletails. The silverfish adult is about 1/2 inch long with a uniform silvery color, whereas the four-lined silverfish is about 5/8 inch long and the back displays four dark lines the length of the body. The gray silverfish is about 3/4 inch long and uniform light to dark gray. The firebrat is about 1/2 inch long and mottled gray. The young resemble the adults.

Life cycle and habits Silverfish and firebrats are active at night and hide during the day. When objects are moved where they are hiding, they dart out and seek new hiding places. The silverfish live and develop in dark, cool places, often in the basement. Large numbers may be found in new buildings where the walls are dark and damp. The firebrat lives in hot, dark places such as around furnaces and fireplaces or insulation around hot water and heat pipes. They follow pipelines from the basement to rooms on lower floors, living in bookcases, around closet shelves, behind baseboards and behind window or door frames.

They are hardy and can live without food for many months. A female silverfish may lay more than 100 eggs during her lifetime. Eggs are laid singly or in small groups, and hatch in three to six weeks. The whitish immatures take on the silver color in four to six weeks. Adults may live two to three years.

Firebrats lay about 50 eggs at a time in several batches. Eggs hatch in about two weeks. Silverfish and firebrats reach maturity in three to 24 months.

Courtesy, University of Florida

Figure 8-5. Silverfish.

These insects normally hitchhike into the home in food, furniture, old books, papers and old starched clothing.

Management Sanitation is important but not entirely effective in reducing populations, because insects often reside between wall partitions, in insulation materials, in books and paper, and in other protected places. However, be sure to remove old stacks of newspapers, magazines, paper, books and fabrics stored for long periods of time, as well as spilled food. Sometimes reducing available water and lowering the home's relative humidity with dehumidifiers and fans is helpful. Lighting a dark, sheltered area may force these insects to move to new sites where they can be controlled more easily. Once the infestation is eliminated, sanitation will help prevent reinfestation.

Insecticides should be thoroughly applied to all potential hiding places such as cracks, crevices, around floor molding, around steam and water pipes, in and behind seldom-moved furniture, under bathroom fixtures and even in attics. It may be necessary to drill small holes in the walls to treat large populations.

- Insecticidal dusts may be effective in hard to reach places such as wall voids, behind baseboards, under insulation in attics, crawl spaces and under commodes.
- Residual sprays may be used.
- Baits may also be effective.
- Space sprays of non-residual insecticides, such as resmethrin or synergetic pyrethrins, directed towards possible hiding places may flush silverfish onto residual treated surfaces.

Psocids or Booklice

Booklice belong to a group of insects collectively called the psocids. The psocids are small soft-bodied insects, most of which are less than 1/8 inch long (Figure 8-6). They are both winged and wingless. Psocids have chewing mouthparts.

The majority of psocids are outdoor species with well-developed wings. They are most commonly found on bark or foliage of trees and shrubs. These psocids are frequently called

Courtesy, University of Florida

Figure 8-6. Psocid or booklouse.

"barklice." Most of the species found in buildings are wingless. Because they are often among books and papers, they are called booklice. The term "lice" in the names is somewhat misleading because none of these insects are parasites and few of them have a louse-like appearance.

Psocids feed on molds, fungi, cereals, pollen, fragments of dead insects or other similar materials. They cause little loss of food because they feed chiefly on mold. At times they may become extremely abundant and spread through an entire building. In such situations they may contaminate foods and materials to the point the goods must be discarded. Damage to books may be more direct because booklice eat the starch sizing in the bindings and along the page edges.

Psocid eggs are laid singly or in clusters and are often covered with silken webs of debris. Most species pass through six nymphal stages. The entire life span from egg to adult is between 30 and 60 days.

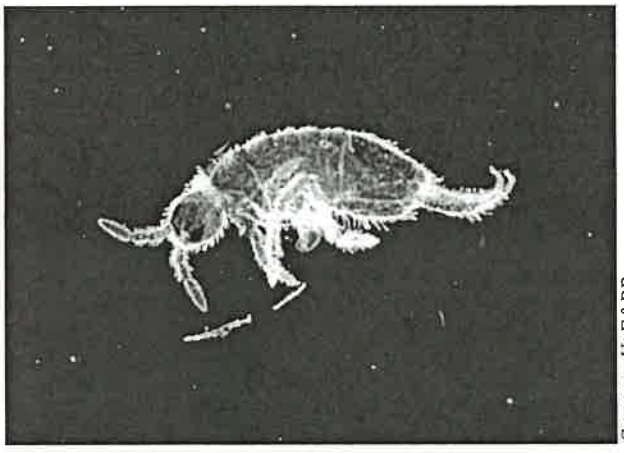
Management Moisture reduction to eliminate mold formation is a very effective method for booklice control. Infested furniture, bedding or other movable furnishings should be thoroughly cleaned and aired. Clean up spilled food products and keep all stored products tightly sealed.

If required, apply a spot treatment of residual insecticide. Aerosol applications reduce numbers but will not provide long-term reductions.

Springtails

Springtails (Figure 8-7) are extremely small insects that become problems in homes and other structures when they invade in enormous numbers. They are very common outside as soil insects. As a result, they fulfill an important role in soil development and enrichment. There may be as many as 50,000 springtails per cubic foot of forest litter. They can also be indoors in potted plants and decaying bulbs.

Description and habits These insects are usually white or gray. They have a forked appendage to the rear and bottom of the abdomen. This appendage, used as a lever, allows these insects to jump or spring into the air, which is how the insects got their name.



Courtesy, Ut E&PP

Figure 8-7. Springtail.

They infest buildings that have constant high humidity. This is usually in the basement, but may be in other areas with water leaks. As a result, the best method of control is to stop the leak or decrease the humidity. Fans may be used to dry out wet areas quickly.

Springtails are attracted to light and may enter homes or other structures under doors. They are a particular problem in newly built buildings with wet materials.

Earwigs

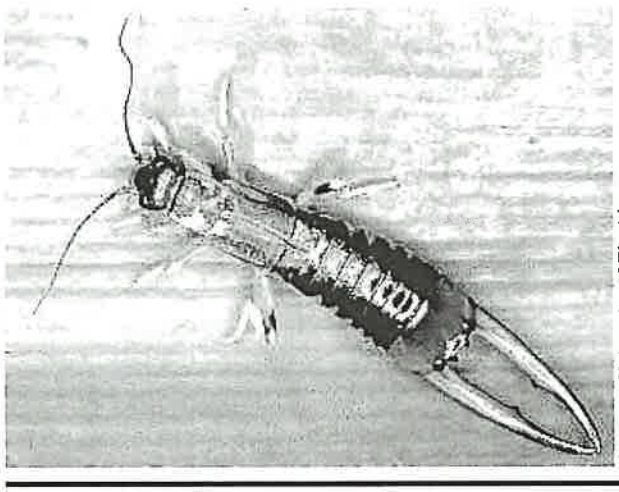
Earwigs are beetle-like, short-winged, fast moving insects. They are about 1/2 to 1 inch in length. They are usually dark brown and have a pair of pincer-like appendages at the tip of the abdomen (Figure 8-8). They have chewing type mouthparts and a gradual type of development.

Earwigs are active at night. They hide in cracks, crevices, under bark or in similar places during the day. They are usually scavengers in their feeding habits, but occasionally feed on plants.

The name earwig is derived from an old superstition that these insects enter peoples' ears. Some species have scent glands from which they can squirt a foul-smelling liquid. This is probably used for protection from predators.

The striped earwig adults are dark brown with light tan markings. The males are large and robust with stout pincers. The females are somewhat smaller and lighter in color than the males. This earwig lives in subterranean burrows or under debris in areas with sandy or clay soils. They are usually outside unless populations are large or other conditions are adverse. They enter structures accidentally, in search of food or a more suitable environment.

Because they are nocturnal, they remain in the soil or under debris during the day. Heavily thatched lawns or mulched flower beds are among their preferred daytime habitats. At night they collect in large numbers around street lights, neon lights, lighted windows or similar locations where they search for food. Favorite foods include armyworms, aphids, mites and scales. They will also forage on food scraps or dead insects.



Courtesy, University of Florida

Figure 8-8. Earwig.

The female lays about 50 tiny eggs in a subterranean burrow. The eggs hatch into nymphs in about seven days and the nymphs feed on their egg case. The female continues to care for the young, grooming and manipulating them in the burrow throughout the first nymphal stage. The young nymphs are about 1/8 inch long and could be very easily confused with termites.

In about seven days, the nymphs molt into the second stage and are released from the burrow by the female. At this time the female loses her maternal instincts and many times will devour the nymphs before they can hide. During later stages, the nymphs tend to be cannibalistic. After passing through six nymphal stages lasting an average of 56 days, the earwig becomes an adult.

Management Earwigs are difficult to control with chemicals. Many times the most effective control for an errant earwig or two in the home is purely mechanical. A vacuum can provide quick control. For severe indoor infestations, insecticide sprays should be used only for spot treatment.

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

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

Sowbugs and Pillbugs

Sowbugs (Figure 8-9) and pillbugs (Figure 8-10) are common crustaceans, belonging to a group of animals called Isopods, and are found throughout Tennessee. They are wingless, oval or slightly elongated arthropods about 1/2 inch in length and slate-gray with the body segments appearing as armored plates.

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

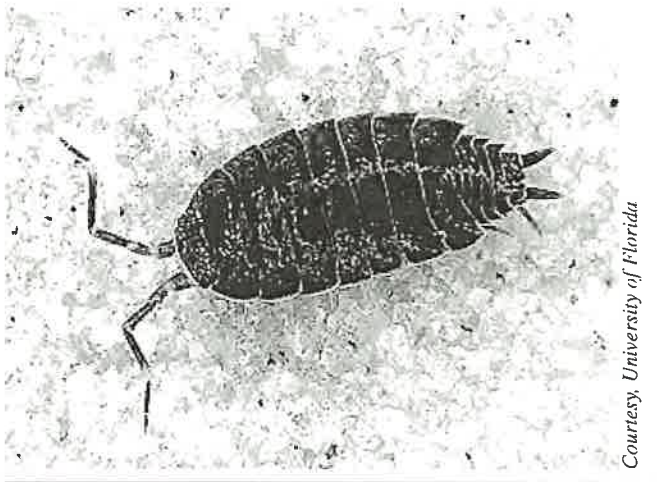
Sowbugs are often called woodlice and possess two taillike appendages, seven pairs of legs and well-developed eyes. They are incapable of rolling into a tight ball. Pillbugs or "roly-polies" lack the tail-like appendages and can roll into a tight ball.

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

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

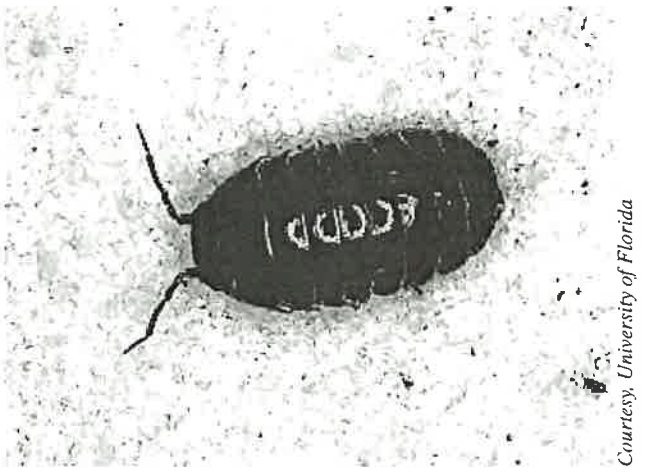
Management Sowbugs and pillbugs cause no damage inside the home. Simple mechanical control such as a vacuum may be adequate. If they become a serious nuisance, elimination of hiding places, food and moisture sources will reduce the infestation. Source reduction outdoors helps considerably. Piles of leaves,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

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



Courtesy, University of Florida

Figure 8-9. Sowbug.



Courtesy, University of Florida

Figure 8-10. Pillbug.

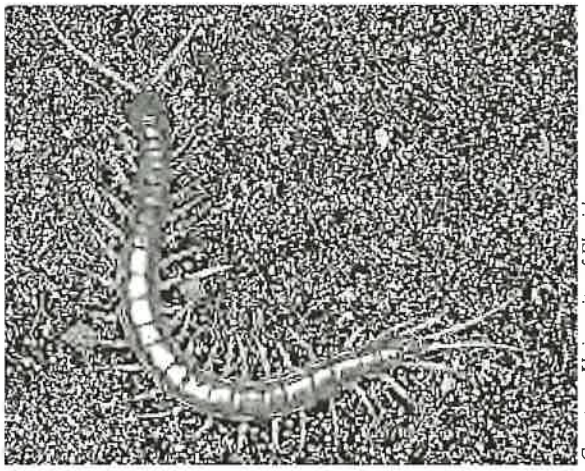
Usually outdoor treatments are necessary to control sowbugs. Treatments should be to and near foundation walls, around steps or damp areas surrounding the structure. Cracks between sidewalks and foundation require thorough treatment. Granules or dusts are also useful for treating around foundations and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

Centipedes and Millipedes

Centipedes (Figure 8-11) and millipedes (Figure 8-12) are commonly seen in yards and occasionally enter homes. Neither centipedes nor millipedes damage furnishings, home or food. Their only importance is that they annoy or frighten individuals.

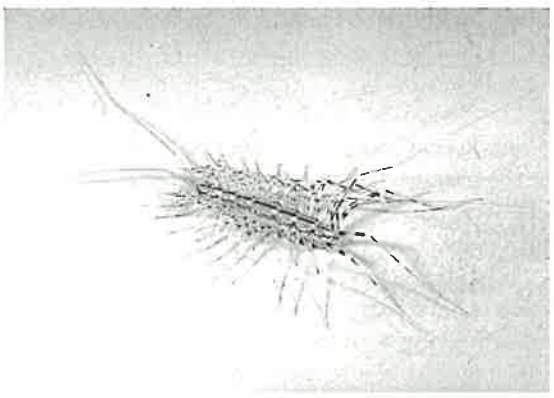
Centipedes are many-legged animals and belong to a group of animals called Chilopods. They are usually brownish and flattened with many body segments. The house centipede has very long, thread-like legs with dark and light bands; the body has three dark stripes. Most of the body segments have one pair of legs. Centipedes are fast runners and may vary in length from 1 to 6 inches. They have one pair of antennae that are easily seen.

Centipedes have poorly developed eyes and are most active at night. They are active predators and feed mainly on insects and spiders. All centipedes have venom glands to immobilize their prey. The jaws of the small local species typically cannot penetrate human skin; however, the larger species may inflict painful bites.



Courtesy, University of Florida

Figure 8-11. Centipede.



Courtesy, R. Bessin, University of Kentucky

Figure 8-12. House Centipede

Centipedes are usually associated with damp, dark places such as under stones, leaf litter, logs, bark or soil crevices. Indoors they may be found in closets and bathrooms where there is high humidity.

Centipedes usually lay 15 to 55 eggs clustered together in the soil, although the eggs of some species are laid singly. The eggs hatch soon after they are deposited. The female will usually guard the eggs and the newly hatched young. Young centipedes closely resemble the adults and require three years to mature. Centipedes are rather long-lived and individuals may live up to six years.

Millipedes are commonly known as "thousand-leggers" and belong to a group of arthropods call Diplopods. Millipedes are wormlike, cylindrical animals with many body segments. Most of their body segments bear two pairs of legs. Millipedes tend to coil up tightly when disturbed and some species can secrete foul-smelling fluid.

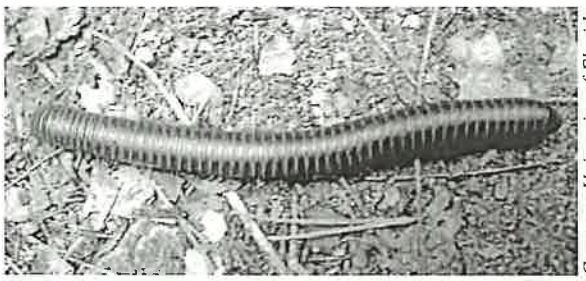
Millipedes feed on decaying vegetable matter and are often found under stones, flower pots, boards or similar debris where there is abundant moisture. Occasionally after rains or during cold weather, large numbers of millipedes may migrate into buildings. They can climb foundation walls and enter houses through any small opening. These pests are generally more troublesome in wooded or newly developed areas where decaying vegetation provides excellent food and breeding conditions.

Female millipedes can lay from 20 to 300 eggs singularly or in clusters in the soil. The eggs hatch in a few weeks, and the young go through seven to eight stages before maturing to adults.

Management One study reduced millipede invasions into a structure by 93 percent using non-chemical procedures. Several techniques were used to reduce moisture levels in the lawn and areas surrounding the structure:

- lawns were dethatched,
- lawns were closely mowed and edged to allow them to dry more quickly,
- debris and mulch were pulled away from the structure to reduce hiding places, and
- grass was watered early in the morning to allow it to dry out later in the day.

As with other pests with high moisture requirements,



Courtesy, University of Florida

Figure 8-12. Millipede.

Courtesy, Texas A&M

Figure 8-13. Scorpion.

millipedes should die indoors after several days. Caulking can also be performed along with other exclusion practices to prevent entry into the structure. Compost piles should be moved away from the structure because they provide food and habitat.

Indoor chemical treatment will eliminate only the centipedes or millipedes already inside. Spot treatments of residual insecticides to infested areas aids in control. Removal of individuals with a broom or vacuum is sometimes sufficient.

A large indoor population usually indicates large numbers of millipedes or centipedes surrounding the structure. Removal of breeding sites and harborages will aid in control. Compost piles and decaying vegetation should be removed from areas close to the home. Outside treatments of residual sprays should help control outdoor populations. Dusts and granules may be applied to crawlspaces and around foundation walls.

Scorpions

Scorpions are flattened, crab-like animals having eight legs, a pair of pincer-like pedipalps, and a fleshy tail ending in an enlarged, upturned tip, which bears a stinger. Two species are found in Tennessee: *Vejovis carolineanus* and *Centruroides vittatus*. *V. carolinianus* (30 - 40 mm long) is found throughout Tennessee in dry places such as sandy soils, rock outcroppings and cedar glades. *C. vitatus* is found in western and southern Tennessee including Clarksville (pers. comm. Drew Beld, Vanderbilt University)

Scorpions are most active at night and feed on insects, spiders or similar small animal life. They are also cannibalistic and will readily feed on other species or smaller individuals of their own. Females will often eat their own young. Young are born live and climb on the back of the mother until after the first molt. When not active, scorpions can be found under boards, rubbish or similar debris which offers shelter and protection.

These scorpions will sting, but usually only when provoked or disturbed. The neurotoxin injected is usually insufficient to prove fatal to an adult; however, the site of the sting may be sore and swollen for some time.

Management Pest proofing the structure is important to deny access to these pests. Seal cracks and openings around pipes and conduits that enter the home. Ventilation openings can be covered with screening. Pay particular attention to openings in foundations and attics. Foundations of stone or block provide suitable harborage for scorpions and must be sealed. To prevent entry into living spaces, the inside of the home (edges of lighting fixtures, plumbing openings, cabinets and baseboards) must also be sealed. Outdoors, remove potential harborage sites including stacks of wood, brick, blocks, etc. Scorpions will also take shelter under railroad ties, rocks, mulch and more.

Scorpions will fluoresce under a black light, so they and their breeding areas can easily be seen at night. Mechanically destroy any scorpions by swatting, crushing or vacuuming. Treat hiding or breeding areas with residual dusts or sprays. Use glue boards to trap scorpions and locate infested areas. Glue boards should be placed against walls and other guidelines where scorpions are suspected. During dry weather, scorpions can be attracted and trapped by spreading moist burlap on the ground around infested areas.

Review Questions

1. Foreign grain beetles feed on _____.
   - A. stored flours
   - B. stored grains
   - C. fungal growth
   - D. none of the above

2. Behaviors used to identify camel crickets are _____.
   - A. loud chirps and wing rubbing
   - B. long chirps and wing rubbing
   - C. high jumping ability and upside down resting state
   - D. high jumping ability and upright resting state

3. Silverfish live _____.
   - A. in dark cool places
   - B. in hot, dark places
   - C. in rooms with silver paint
   - D. in ponds or other small bodies of water

4. Springtails infest buildings that have _____.
   - A. constant high humidity
   - B. stored furs, including fur tails
   - C. stored spring mechanisms
   - D. low humidity

5. An earwig is an insect that often rests in peoples' ears and in the past used to rest under wigs.
   - A. true
   - B. false

6. Which is not a part of an earwig management program?
   - A. trapping with jars or tin cans baited with fish
   - B. reapplying insecticide applications
   - C. mechanically removing errant ones in homes
   - D. planting onions to repel them

7. Sowbugs and pillbugs usually feed on _____.
   A. live insects
   B. decaying organic material
   C. old medicine pills
   D. fresh flowers

8. Centipedes and millipedes damage _____ in homes.
   A. furnishings
   B. food
   C. walls
   D. nothing

9. Centipedes feed on _____.
   A. live insects
   B. decaying organic matter
   C. old medicine pills
   D. fresh flowers

10. Millipedes feed on _____.
   A. live insects
   B. decaying organic matter
   C. old medicine pills
   D. fresh flowers

11. Which do not coil or roll up when disturbed?
   A. pillbug
   B. centipede
   C. millipede
   D. all of the Above

12. One study reduced millipede invasion into a structure by _____ percent using non-chemical control.
   A. 93
   B. 83
   C. 73
   D. 53

Answers: 1. C, 2. C, 3. A, 4. A, 5. B, 6. D, 7. B, 8. D, 9. A, 10. B, 11. B, 12. A

Chapter 9 Vertebrate Pests

The most common vertebrate pests found in or around buildings are rats, mice, bats and birds. Occasionally other vertebrates such as snakes, lizards, skunks and squirrels enter buildings, although they are usually nuisances rather than destructive pests. Rats and mice, however, are troublesome because they are well adapted to live with people and they destroy or contaminate food and fabrics, cause structural damage and are primary or intermediate carriers of transmissible disease organisms.

Bats and birds do not live intimately with people, but many species use buildings for nests or roosts. They produce smelly and unsightly urine and droppings, are noisy, build messy nests and may have several insect and mite pests living on their bodies or in their nests. There is also a concern that bats can be infected with rabies. Bats and birds may be capable of harboring or contributing to several diseases, such as histoplasmosis. Using pesticides to control birds requires a BDC license.

Managing vertebrate pests requires special skills because these animals are large and more intelligent than invertebrates. Vertebrates may learn to recognize and avoid some control attempts; therefore, an integrated and persistent approach is needed. It is necessary to understand their habits and food preferences to monitor and manage population levels effectively and economically; otherwise you may get poor control or even increase the problem.

Rodents

Rats and mice are remarkably well-adapted for living in close association with humans. The greatest economic loss is not from the products these rodents eat, but items that must be discarded due to damage or contamination. Food, clothing, furniture, books, and many other items are contaminated by their droppings and urine or damaged by their gnawing. Rodents damage doors, walls, insulation and other structural components by their gnawing and burrowing. They also gnaw through utility pipes and electrical wiring, causing fires, indoor flooding, power outages and equipment failure.

Rats and mice can also transmit disease-causing organisms, most notably those that cause salmonellosis (bacterial food poisoning), when food is contaminated by infected rodent feces. Other rodent-borne diseases include plague, murine typhus, rat-bite fever, rickettsial pox, hantavirus and others.

Description, Biology, and Habits

Three common species of rodents live in close association with humans: the Norway rat, roof rat and house mouse (Figure 9-1).

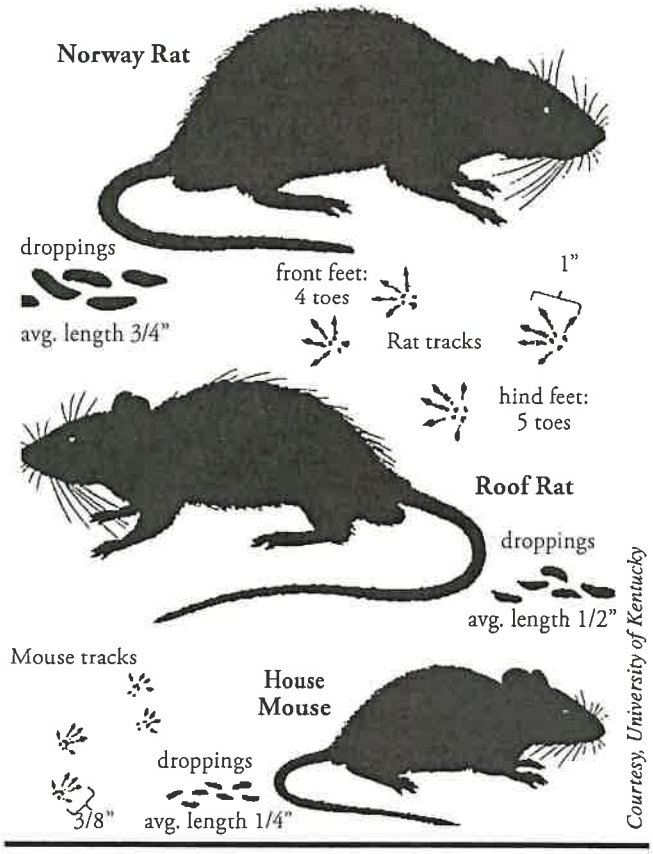


Figure 9-1. Rodent adults, tracks and feces.

Norway Rat The Norway rat (Figure 9-2), also called the brown or sewer rat, is the largest domestic rodent. An adult weighs about 12 to 20 ounces, and the body is stocky and covered with coarse, reddish brown fur. The head is small, with close-set ears and a blunt muzzle. The tail is shorter than the combined length of the head and body. Adult droppings (Figure 9-1) are about 3/4 inch long, capsule-shaped, with blunt ends.

Norway rats live about one year and reach sexual maturity in two to three months. Females have four to six litters each year with six to 12 young per litter.


Courtesy, USFWS

Figure 9-2. Norway rat.

Outdoors, Norway rats commonly nest in burrows alongside buildings, fences and under bushes or debris. They use the same routes daily and their feet make a beaten path or runway along the ground. Indoors, Norway rats prefer to nest in the lower portions of buildings in wall voids, underneath floors, in crawlspaces, and beneath or inside equipment or stored items.

Norway rats eat essentially the same foods as humans, including meats, vegetables and cereal grains, as well as garbage. They require water each day when feeding on dry food. Rats tend to be more cautious than mice in their foraging and feeding habits. Their average foraging range from the nest is about 50 – 150 feet, but they will travel further if food or water is scarce. Like all commensal rodents, Norway rats are nocturnal (active primarily at night), and they prefer to travel adjacent to walls and edges.

Roof Rat Roof rats (Figure 9-3) are much less common in Tennessee, but are occasionally encountered. These rats are smaller and sleeker than the Norway rat, weighing about 8 to 12 ounces when fully grown. The tail is longer than the combined length of the head and body, the muzzle is pointed and the ears are large (Figure 9-1).

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

Roof rats consume many types of foods, but prefer vegetables, fruits, seeds and cereal grains. Droppings are about 1/2 inch long and spindle-shaped (pointed) on one end (Figure 9-1).

House Mouse The house mouse (Figure 9-4) is the smallest domestic rodent. Adults are 2 1/2 to 3 1/2 inches long, with a 3- to 4- inch semi-hairless tail. House mice are gray to brown, and have large ears. Mouse droppings are 1/8 to 1/4 inch long with at least one of the ends pointed.

House mice only live about a year, but are prolific breeders. Females produce six to 10 litters continuously throughout the year with four to seven young per litter. House mice may live indoors or outdoors. Outdoors, they often live among weeds and shrubbery or near building foundations, inside

Courtesy, Clemson University

Figure 9-3. Roof rat.

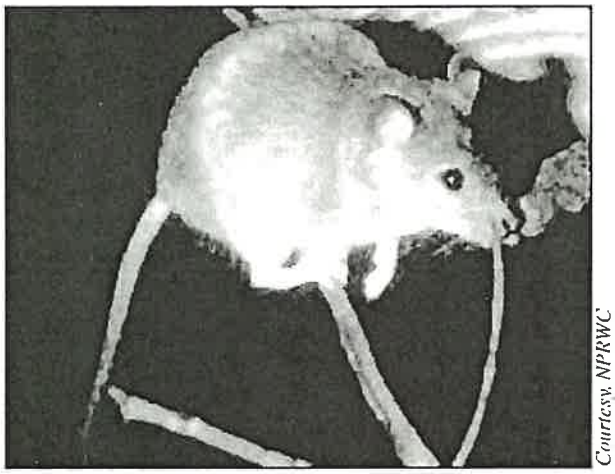

Courtesy, NPRWC

Figure 9-4. House mouse.

garages, crawl spaces or outbuildings. When food becomes scarce in the fall, mice often move indoors. Inside buildings, mice commonly nest within walls, ceiling and cabinet voids, furniture and large appliances.

Mice feed on a wide variety of foods but prefer seeds and cereal grains. They are also fond of foods high in fat and protein, such as nuts, bacon, butter and sweets (a useful point to remember when selecting baits for snap traps). Mice are "nibblers" and may make 20 to 30 visits to different food sites each night. Compared to rats, mice forage only short distances from their nest, usually not more than 10-25 feet. When food and shelter are adequate, their foraging range may be only a few feet. For this reason, traps and other control devices must be placed in areas where mouse activity is most apparent. Similar to rats, mice prefer to travel adjacent to walls and other edges (another important point to remember when positioning control devices). Mice are very inquisitive and will investigate each new object placed in their foraging territory. Therefore, if control devices are not initially successful, try moving them to a different location.

Control

To control rats and mice, you must "think like a rodent." Keep in mind the behavioral traits noted above for each species. Begin with a thorough inspection of the premises, relying on the following signs as indicators of rodent activity:

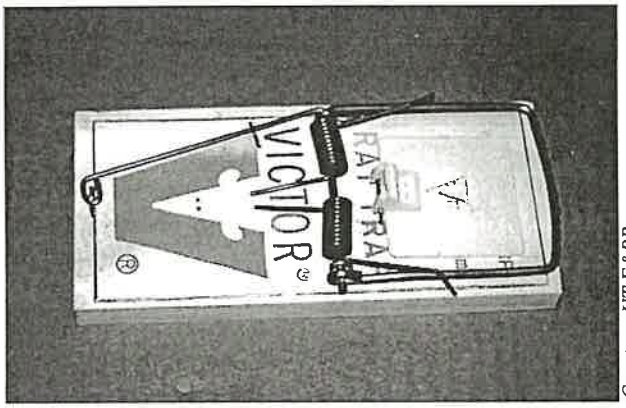
Figure 9-5. Norway rats prefer to nest in burrows.

1. Droppings are the most common indicators of rodent presence and provide valuable clues where to place control devices. They are likely to be found where rodents travel, near their shelters or other places rodents frequent. The shape and number of droppings can tell the species of rodent involved, the approximate size of the infestation and whether the infestation is old or new. Fresh droppings are usually soft, shiny and dark but can become hard in a matter of hours. Old droppings are dull and often covered with dust. Active infestations are best determined by removing old droppings and noting the presence of new droppings.
2. Runways/Rub Marks — Rodents are creatures of habit. They consistently use the same routes between food, water and harborage. Outdoors, runways can be found next to walls, along fences and under vegetation. Active runways are smooth, well-packed and free of vegetation. Indoors, runways may be found along walls, edges and between stored items. As a rat moves along walls and through tight spaces, its body hairs often leave a dark, greasy deposit on surfaces. These "rubmarks" may be seen at ground level (along floor-wall junctions) or overhead beneath beams and rafters.
3. Burrows — The Norway rat prefers to nest in burrows (Figure 9-5), whereas the roof rat and house mouse only burrow occasionally. Rat burrows are usually found under concrete slabs, alongside building foundations or beneath shrubbery and debris. Active burrows usually are smooth and compacted at the entrance, and free of dust and cobwebs. To determine if a burrow is active, stuff wads of paper into the opening or cave in the burrow with soil and recheck it the following day. Rat burrows usually consist of a main entrance and two or more "bolt" holes.
4. Tracks — Rodent footprints or tail marks can sometimes be found on dusty surfaces or in mud. To better see tracks in dust, hold a flashlight so that the beam is directed across the tracks at an angle. A tracking patch made of talc or flour also can help to determine if rodents are present.
5. Gnawing Marks — Mice and rats gnaw on all types of objects. Mice often gnaw small, clean-cut holes about 1 inch in diameter in boxes, bags, door sweeps, etc. Gnaw holes from rats are larger (about 2 inches in diameter), and often contain rough, torn edges. Rats often gnaw on the bottom of wood doors, joists and other structural members.
6. Urine — Rodent urine will fluoresce under a black light.
7. Sounds — Rodents make sounds when gnawing, feeding, fighting or moving around.
8. Visual Sightings — Use a flashlight or a spotlight at night. Seeing rodents in the daylight indicates a high population.
9. Nest and food caches — Found in attics and other undisturbed areas, including diverse shrubbery, food and nest caches are often indicators of rodents.
10. Pet excitement — Cats or dogs may probe an area of floors or walls where rodents are nesting.

Sanitation Rodents must have food and shelter to survive. Whatever can be done to limit availability of these essential resources will help to reduce rodent problems. This is especially true for rats, which require considerably more food, water and shelter than mice. Garbage should be kept in rodent-proof containers and picked up regularly. The same is true for pet food and bird seed. Weeds and unnecessary vegetation should be removed, especially when they are adjacent to building foundations. Weeds serve as rodent harborage, and weed seeds are a favored food of mice. Rubbish, lumber, rock piles, standing water and old equipment should be eliminated. Where practical, boxes, crates and other items should be stored at least 18 inches off the ground and 12 inches away from walls. Storing items in this manner makes them less attractive to rodents. It also facilitates inspection, cleaning and installation of rodent control devices.

Rodent-Proofing Along with proper sanitation, the best way to avoid rodent problems in buildings is to prevent their entry (Figure 2-13). Mice are able to squeeze through extremely small openings no wider than the diameter of a pencil (1/4 inch). Rats can enter through cracks no wider than the diameter of a dime (1/2 inch). Cracks and openings under doors, around windows and in building foundations; vents; and where plumbing, electrical and air conditioning lines enter the structure should all be sealed. Permanent sealants such as cement, sheet metal and hardware cloth are preferred.

Traps and Glue Boards Trapping can be a very effective form of rodent control, especially against mice. If signs indicate that you do not have a large rodent population, traps are generally preferred over pesticides because they are less hazardous to use around children and pets. In addition, because rodents are captured by the trap, they are not as likely to die in walls or other inaccessible areas and create odors. Snap traps are widely available and easy to use. Trapping efficiency can be enhanced by baiting the trigger with such foods as peanut butter, bacon, raisins or fruit. Snap traps with an expanded trigger (Figure 9-6) catch significantly more mice than conventional designs. Snap traps should be oriented perpendicular to the wall, with the trigger end against the vertical surface (Figure 9-7). Lean a board over the snap trap to force rodents to walk over the trap.



Courtesy, UT E&PP

Figure 9-6. Snap trap with expanded trigger.

Another very effective trap against mice is the automatic, multiple-catch trap (Figure 2-20). Mice enter these traps out of curiosity for new objects placed in their territory. One type of multiple-catch trap requires winding and flips mice into a holding chamber. Another model operates using the principle of a trap door. Both devices can capture and hold several mice before needing to be emptied. Multiple-catch traps can be oriented with the entrance hole either perpendicular or parallel to the wall.

Glue boards are also very effective against rodents, especially mice. Mice become entangled in the glue when they run over the boards. Captured mice soon die of suffocation. Along with traps, glue boards are a preferred method of control in homes and other sensitive locations where pesticides are a concern. Should the glue from a glue board contact the fur of a pet or the skin of a child, it can be removed with mineral or vegetable oil.

Regardless of which type of trap or glue board is used, placements should be installed up against walls, behind objects and appliances, and in secluded areas where droppings, damage and other signs of rodents are evident. Rodent control devices should also be installed in areas where there is potential for rat or mouse entry (e.g., on both sides of exterior doors, and near utility openings in walls).

Rodents have limited foraging ranges; therefore, it's important to use several trap placements. For mice, traps and glue boards should be spaced no more than 10 feet apart in areas where mouse activity is apparent — closer if the infestation is severe. Rat traps can be spaced 15 to 20 feet apart.

Traps and glue boards should be checked daily, and dead rodents disposed of in plastic bags. Gloves should be worn when handling rodent carcasses to prevent spreading disease organisms. Records should be kept indicating where each control device was installed and which placements caught rodents. Decomposing rodents attract flies, dermestid beetles and other insects that can lead to additional problems if not removed. Keeping trap catch records also helps to identify persistent areas of rodent activity. Adjustments to the rodent control activities in these areas (e.g., adding more traps, exclusion, weed control) can then be made accordingly.

Rodenticides Specific pesticides, known as rodenticides, are available for rodent control. The three main types are poison baits, tracking powders and fumigants.

Poison Baits Most rodenticides are formulated as food-based baits containing seeds or grain to attract the rodents. Many baits are anticoagulants containing brodifacoum, bromadiolone, chlorophacinone, diphacinone or warfarin as active ingredients. These toxicants kill by interfering with normal clotting of the rodents' blood, causing the rodent to die from internal bleeding. The newer anticoagulants (e.g.,

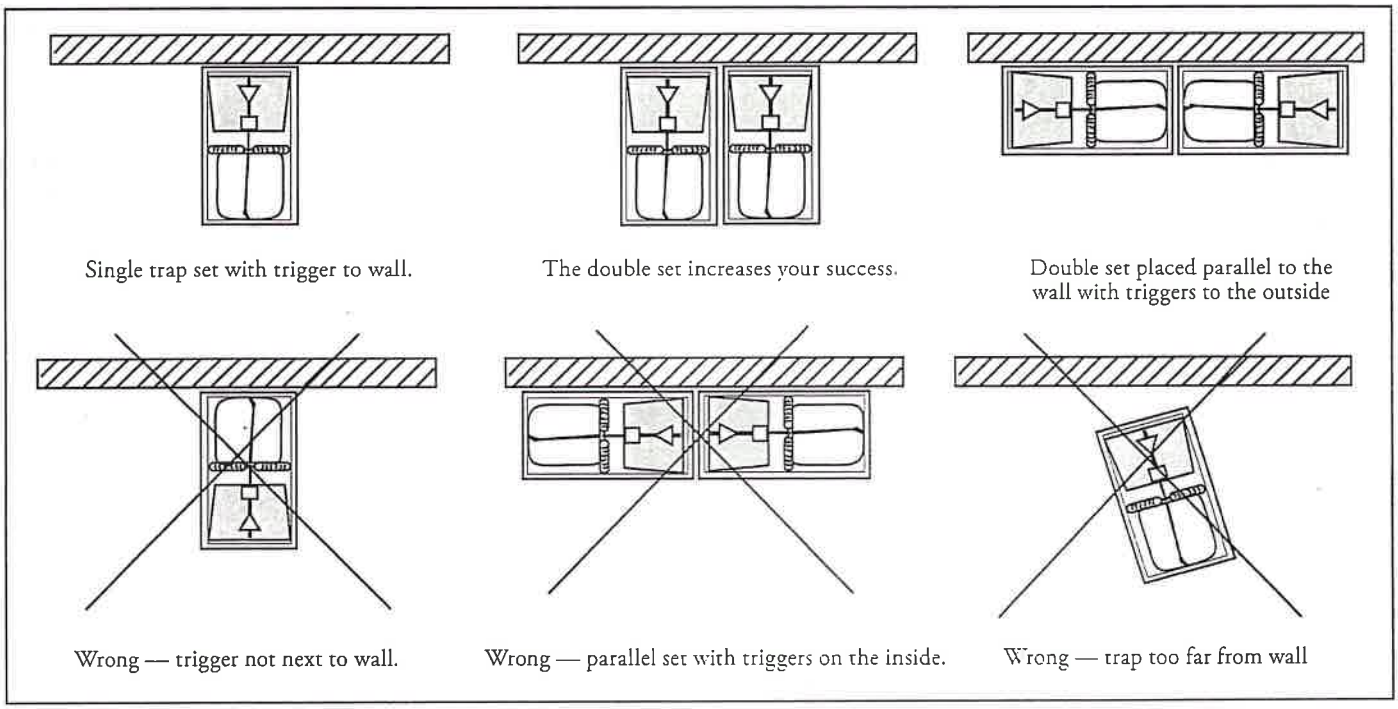


Figure 9-7. Snap traps should be oriented perpendicular to the wall, with the trigger against the vertical surface.

brodifacoum, bromadiolone) are normally lethal to rodents after a single feeding. Nonetheless, three to five additional days are typically required for the rodent to die. The older anticoagulants (warfarin, chlorophacinone, diphacinone) required several feedings by the rodent and two or more weeks for death to occur.

Non-anticoagulant rodenticide baits are also available. Most of them kill rodents after a single feeding. Bromethalin kills rodents in two to three days by causing paralysis of the nervous system. Cholecalciferol causes an excess of calcium in the blood, leading to heart failure in three to four days. Zinc phosphide kills rodents in 1 – 24 hours by forming phosphine gas in the circulatory system.

Commercial baits, in pellet or meal form, are available in sealed plastic, cellophane or paper packets (known as "place" packs), as loose bait or molded into paraffin (wax) blocks. The wax block formulation is very useful for both outdoor and indoor baiting locations because it resists dampness and moisture. Regardless of which bait formulation is used, extreme care must be taken to position baits in areas inaccessible to children, pets and wildlife or in tamper-resistant bait stations. Dogs, in particular, will seek out and find baits placed in areas that are accessible.

Other than when placing baits directly into a rodent burrow, it makes good sense to confine baits in an enclosed bait box. Bait boxes help to (1) reduce accidental contact with people and nontarget animals, (2) keep bait fresh by protecting it from dirt, moisture and dust, (3) provide a protected and attractive place for rodents to feed, and (4) allow label, company contact number and other pertinent information to be provided at the baiting site. If rodent bait cannot be installed in locations inaccessible to children and nontarget animals, it must be placed in tamper-resistant bait boxes. These boxes are constructed of metal or non-crushable plastic, are equipped with a locking mechanism, and have a specific internal design for confining bait within the station (Figure 3-3). To be considered truly tamper-resistant, the station must also be secured to the mounting substrate (ground, floor, wall, fence, etc.). This can be done with a stake, nail gun, length of chain, "liquid nails" or by securing the station to a weighted paving block.

As with traps, proper bait placement is critical. Place bait in all areas suspected of harboring rodents, along routes of travel and where they are likely to enter the building. Several placements will produce better results than just a few. Baits that are not being fed upon may need to be repositioned. Rodent bait should be replaced at least monthly, because rats and mice are not attracted to old, moldy bait.

Tracking Powder Some rodenticides are formulated as "toxic dusts," known as tracking powders. Tracking powders may contain anticoagulants (e.g., chlorophacinone, diphacinone) or non-anticoagulants (e.g., zinc phosphide) as toxicants. Small amounts of tracking powder are placed in known rodent runways, burrows, wall voids and other concealed locations, usually via a hand duster. Rodents pick up the toxicant on their fur and feet and ingest it while grooming. Tracking powders are especially effective against mice, which groom themselves and their nest mates continuously. Tracking powders should only be placed in inaccessible areas or in the bottom of tamper-resistant bait stations. As with any pesticide, care must be taken not to contaminate food preparation surfaces or other surfaces that may be contacted by people or pets. Care must also be taken to prevent rodents from spreading these toxic dusts onto food preparation surfaces or areas that may be contacted by people or pets. Because of the extreme liability when using this rodenticide formulation, it is probably best to avoid its use whenever possible.

Fumigants Certain rodenticides are also formulated as poisonous gases (fumigants). The most common use of these products is for burrow gassing. Gassing rodent burrows with a fumigant is a fast and effective way to control burrowing rodents (e.g., Norway rats) in outside locations. The most common fumigant used for burrow gassing is aluminum phosphide, formulated as tablets or pellets. The product is placed in the burrow with a gloved hand, and the gas releases slowly as it reacts with ground moisture in the burrow. Fumigants can be extremely dangerous if used incorrectly. Applicators should always remember to read the pesticide label before use and must be under the supervision of an operator licensed in fumigation.

Wildlife

Wildlife damage management is the specialized area of wildlife management that works to reduce or eliminate individuals of one or more species of wildlife or the problems they are causing in a specific area. The first step in solving a problem is identifying the species causing the problem. This is accomplished by looking for signs of the problem animal(s) such as tracks, scat or hair. The feeding pattern of a particular species also may give away its identity. Obviously, the best way to identify the problem animal is to catch it in the act. Once the species is identified, known characteristics about the species' ecology are used to reduce or eliminate the damage.

A number of strategies are employed to accomplish this goal, including eliminating habitat, exclusion, frightening, repelling, relocating and dispatching offending individuals. More than one of these strategies may be necessary to solve a problem. Generally, multiple techniques are more effective than any one technique.

The timing of a wildlife damage abatement program is critical. It is important to understand that wildlife damage is easier to prevent than stop. Wildlife, like humans, are creatures of habit. When animals find that a particular area is a good place to relax, hide, den, eat, hunt or visit for some reason, they normally establish a pattern of use and become difficult to move. This problem may be compounded if many animals are using the area or the animals have used the area for an extended period of time. An aggressive, persistent damage reduction campaign may be necessary to solve the problem. Where wildlife damage is known to be seasonal, steps should be taken ahead of time to deter the problem. If no history of wildlife damage exists, action should be taken immediately upon discovering damage.

A major concern with any wildlife damage control project is the legal status of the offending animals. Most wildlife, except specific introduced species (e.g., house mice, Norway rats, European starlings, house sparrows and pigeons), fall under the protection of either the federal or state government. Non-migratory species are protected by the state. In Tennessee, this includes mammals, upland game birds, reptiles and amphibians. The Tennessee Wildlife Resources Agency (TWRA) has primary responsibility for these species. Tennessee law allows landowners who suffer wildlife damage to take action without a permit when most of these species are causing a problem. Exceptions include game animals (e.g. white-tailed deer); however, when serious damage is occurring shooting permits may be obtained from TWRA. Pest management professionals or any person, company or other entity desiring to destroy or otherwise control nuisance wildlife and charge a fee for such services must first obtain an Animal Damage Control Permit from the Tennessee Wildlife Resources Agency. (See rules of the Tennessee Wildlife Resources Agency, Chapter 1660-1-21, Rules and Regulations for Nuisance Animal Damage Control in Appendix C.)

Migrating birds and threatened and endangered (T&E) species fall under the jurisdiction of the federal government. Generally, techniques to prevent damage from migratory species (e.g., waterfowl, songbirds, wading birds) do not require a permit; however, permits are required for techniques that involve destroying nests or individuals. Any activity negatively affecting T&E species requires approval from the US Fish and Wildlife Service. Generally, it is illegal to harm or harass T&E species in any way. Prior consultation with USDA Wildlife Services personnel is required prior to federal permits being issued for damage control activities associated with federally protected species.

Bats

Bats are highly beneficial wild mammals. They are not flying rodents but belong to a unique order of mammals called Chiroptera (chiro = hand, ptera = wing). Bats are more closely related to primates (monkeys and humans) than they are to rodents. There are two families and 18 species of bats in the eastern United States. All these bats feed on night-flying insects. Each bat eats about its weight in food every night. This means that even a small colony, numbering several hundred individuals, consumes hundreds of pounds of insects every week. These insectivorous bats have tiny sharp teeth for chewing insects. Bats cannot use their teeth to gnaw wood or wires as can rodents with their chisel-like incisors.

During the day bats rest in dark secluded roosts, such as caves, hollow trees, under bridges, crevices and the attics of buildings. In winter when insects are scarce, some bats migrate, while others hibernate in caves, trees or buildings. Most bats enter torpor (a form of deep sleep) during the day and on winter nights when it is too cold for their insect prey to fly. Most bat species have only one young per year; therefore, it takes bat populations a long time to recover from human destruction. Bats are long-lived animals. The little brown bat is known to live up to 30 years. Bats are creatures of habit and will frequent the same roost year after year, even if they only use it seasonally.

Bats are often feared as carriers of rabies. Bats can become infected with the rabies virus, as can skunks, dogs, cats and raccoons. But, unlike these animals, rabies-infected bats do not generally become enraged and attack people or other animals. Normally, they become paralyzed and die quietly. The infection rate for house-dwelling bats is very low, ranging from one per 2000 (0.05 percent) in the southeastern bat to four per 1,130 (0.35 percent) in the Brazilian free-tailed bat.

Management

Removing Single Bats from a Building — Despite their importance as insect predators, bats can be a nuisance when they choose to live in houses, buildings or other structures used by people. Problems such as noise, smell, accumulations of feces (guano) and urine, staining and spotting of surfaces, attraction of other pests such as flies or cockroaches, and the general fear of these mammals by the public may require that they be excluded from a structure.

Single bats occasionally enter buildings accidentally. This usually occurs in the spring or fall, when bats move between winter roosts and maternity roosts, or in the late summer when young bats have just learned to fly. Young bats can become confused, get lost and turn up inside buildings where they don't belong. In most cases, all that is required is that access for escape be provided by opening a door or window. In cases where that is not possible, as in most air-conditioned buildings, a bat can be captured by covering the resting individual with an empty coffee can. Then gently slide a piece of cardboard or heavy paper between the container and the surface on which the bat is resting, trapping it inside. Small groups of bats, numbering fewer than 10 individuals, can also be removed in this way. If a small bat is resting quietly, it may be possible to pick it up while wearing heavy leather gloves. Never touch a bat with bare hands; it will bite to defend itself, as would any wild animal. Do not try to catch a flying bat; this is almost impossible and usually results in injuring the animal. After the bat is captured, take it outside, away from children and pets and let it fly away or place it high on the side of a tree or wall to fly away on its own. A torpid (cold and sleepy) bat will need to "warm up" before it can fly.

If anyone is bitten, cleanse the wound thoroughly with soap and water and call your county health department for information and instructions. Try to collect the bat so it can be tested for rabies. NEVER pick up a bat you find lying on the ground. Keep children and pets away from it, and if necessary, move it to an inaccessible spot. Call the county animal control office to have the bat removed.

Confirming the Presence of Bats in a Building — The presence of a bat colony in a building is often confirmed by seeing bats emerge from various openings at dusk. Squeaking and rustling noises coming from ceilings and walls may indicate a bat colony is present, but these sounds may also come from mice or flying squirrels. Chirping noises coming from chimneys are usually made by nesting chimney swifts, which are small insect-eating birds. An opening, which can be as narrow as 1/4 inch, with a dirty stain below it may be the exit hole for bats. Stains come from urine, feces and body oils deposited around the opening as bats enter or leave the

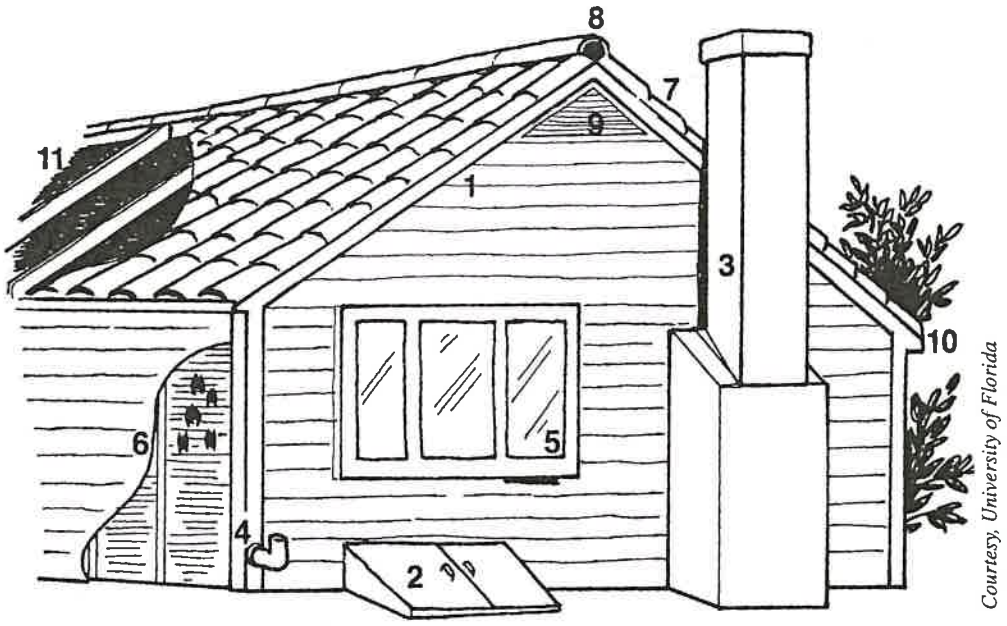


Figure 9-8. Common points of entry and roosting sites of bats in buildings.

roost. Droppings on sidewalks, ledges, patios or underneath rafters in an attic or barn may indicate bats are present. Bat droppings, which are brown or black and resemble instant rice grains in size and shape, are composed entirely of insect parts. Mouse droppings are similar in size and shape but do not crumble between your fingers to reveal bits of insects. Cockroach droppings are usually smaller and have six flattened sides, making them hexagonal in cross section.

Bat Proofing - As with most nuisance animal situations, preventing a problem is much easier and cheaper than correcting one (Figure 9-8). To prevent bats from establishing themselves in a building, all attic and soffit vents should be screened with 1/4-inch hardware cloth or screen. Good ventilation of attics discourages bats from roosting and also discourages infestations of large peridomestic cockroaches. Vent holes in Spanish tile roofs should be covered with screen that is held in place with silicone caulk. Gaps in siding, spaces under warped fascia boards, spaces between house and chimney, and loose flashing and moldings should be sealed to exclude bats and other invading household pests

Excluding a Bat Colony — When bats become established in a building where they are not wanted, the best and most permanent solution is exclusion. This is accomplished by the following steps:

1. Observe the building at dusk from all angles on three or four consecutive evenings to identify the entrance and exit openings that the bats are using.
2. Seal and bat-proof all other openings that bats do not use, but might use in the future. Some species of bats can enter through a crack or crevice that is only 1/4 inch wide. Sealing materials include caulking, wood, sheet metal, plaster, cement, 1/4-inch hardware cloth or window screen.
3. Plan to do the exclusions in the spring or fall. Bats give birth in the summer.
   Exclusions must <u>not</u> be attempted when baby bats are

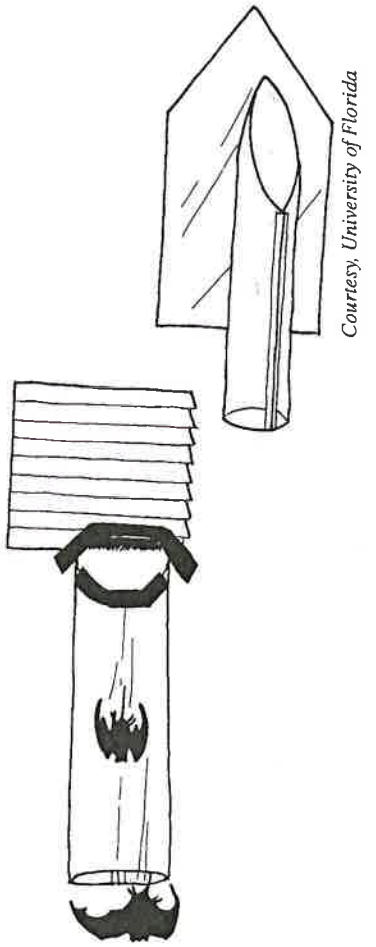


Figure 9-9. Plastic sleeve used as one-way device to exclude bats.

present, as they do not fly with their mothers until they are almost full grown. Baby bats trapped in the roost will die of thirst or starvation and create a serious odor and fly problem. Wait until the young are flying to exclude the colony. Avoid exclusions during cold weather because bats usually do not fly when temperatures are below 45 degrees F.

4. Exclude the unwanted bats by placing one-way devices on each of the colony's exit points.
   These devices can be as simple as a plastic "sleeve" (Figure 9-9). Once the bats exit the sleeve, it collapses behind them. Bats cannot climb or crawl on smooth plastic. Bat netting works the same way. The top of the netting is attached securely to a wall, beam or other solid surface above the roost opening and extends over it. The bottom of the netting is secured at spots along the bottom edge. The netting can be secured with duct tape, staples, velcro tabs, or silicone rubber caulking. The bats exit the roost, crawl out the bottom of the netting, escape, but are not able to find the roost opening when they return from feeding because the netting covers the hole. Professional bat exclusion specialists have developed a variety of exclusion devices for special situations. Colonies in large structures or in high dangerous places should be excluded by experienced professionals. Returning bats may fly around the roost openings, but will disperse within a day or so.
5. Once excluded, a large bat colony may leave behind external parasites such as bat bugs, soft ticks or mites. Most bat parasites are host-specific and will not bite people. Once the bats have been excluded, the application of a desiccant or insecticidal dust throughout the roosting site will kill parasites. This is a good precaution to prevent spread of the parasites while they look for other hosts. Check the CDC Web site (http://cdc.gov) for current guidelines to remove bat guano from buildings.
   Bat guano dries to form a crumbly, powdery substance that can grow a fungus called *Histoplasma capsulatum*. Spores from this fungus become airborne when the guano is disturbed. Inhaled spores develop into a yeast-like infection in the lungs. This produces a systemic disease called histoplasmosis, the effects of which can range from flu-like symptoms (in most people) to serious lung abscesses and lesions resembling tuberculosis (in a minority of others). When working in an area where bat guano is present, wear protective clothing and a cartridge respirator (capable of filtering particles as small as 0.3 microns) to avoid breathing guano dust. Prior to removing accumulated guano, spray it with water to hold down the dust.
6. Permanently seal roost openings when you are sure all of the bats have left the roost.

Leave the excluder in place for at least three days in warm weather, longer in cool or cold weather.

Other Methods of Bat Exclusion — Bright lights can be used to discourage bats from roosting in large structures that are difficult to seal, such as warehouses, barns or similar buildings. Fiberglass insulation also discourages bats from roosting; this is probably due to the irritating nature of this material. Ultrasonic sound emitters for control of bats are expensive ($20 to $70), and there is no scientific evidence to indicate that they actually work. The animals simply move into sound shadows to avoid the sound.

NO POISONS OR FUMIGANTS ARE LEGAL OR REGISTERED FOR CONTROL OF BATS. Poisoning a bat colony exposes people, especially children and pets, to large numbers of dead and dying bats, thus increasing the chance of someone being bitten by picking up a sick animal. These bats also produce odors and subsequent insect problems. Exclusion is the only recommended permanent solution to an unwanted bat colony in a building and does not require a nuisance animal permit. A nuisance wildlife permit is required to capture or kill any bats.

Raccoons

"Coons" are omnivorous mammals, eating both plant and animal foods, including fruits, berries, nuts, corn, crawdads, fish, clams, frogs, snails, insects, turtles, eggs, and small rodents and birds (including many young game birds). Raccoons frequent back porches and garages where dog or cat food is kept outside and oftentimes become problematic about the time sweet corn is ripening in the garden.

Many problems caused by raccoons can be cured with common sense. Raccoons can be kept from getting into crawl spaces under houses, attics, out buildings and garages by excluding them with boards or hardware cloth. Pet food should be brought inside at night or pets may be fed in the morning so that no food is left outside overnight. Raccoons are less attracted to garbage if table scraps are not included.

Electric fencing is the most effective method in keeping raccoons out of patches of sweet corn or other similar areas. Small gardens do not require a lot of fencing material, making this method quite efficient, especially since the materials can be used year after year. Two-strand electric fences, with one strand 6 inches above ground and the other 12 inches above ground are recommended.

Raccoons can be trapped using cage-type live traps baited with sweet corn, sardines or canned fish-flavored cat food. As with other species, place a small amount of the bait outside of the trap and just inside the trap. The rest of the bait should be placed in the back of the trap behind the treadle. When using this set-up, place the trigger of the trap on top so squirrels cannot trip the trap. Bait should be placed above the trap and out of sight of birds.

There are no repellents, toxicants or fumigants registered for raccoons. All coons should be handled with caution — especially those that appear lethargic or unusually aggressive as raccoons have been identified as the major host of rabies in the United States.

Skunks

Skunks frequently dig and den under houses and other buildings. To remedy this situation, seal or cover all foundation openings with hardware cloth, sheet metal or concrete. Burying hardware cloth vertically 1 1/2 to 2 feet deep around

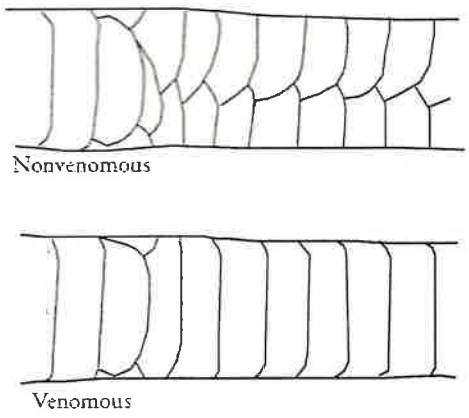


Figure 9-10. Characteristics to distinguish between venomous and nonvenomous snakes.

foundations will help prevent digging activity. The following steps are suggested for removing skunks under buildings:

1. Seal all possible entrances, except the main one.
2. Sprinkle a layer of flour 2 feet wide on the ground in front of the opening.
3. Place a light under the building; skunks don't like bright light.
4. After dark, check for tracks.
5. When tracks indicate the skunk has left, close the last entrance.

Skunks may be trapped in live box traps by baiting with sardines or cat food. If the trap is covered with burlap, captured skunks cannot see the handler and should not spray. They then can be carried carefully to another location where they may be released or killed (which may be preferable because of the risk of spreading rabies from one location to another).

If the skunk sprays, it may be possible to remove the odor with various solutions. There are several commercial products available for removing skunk odors. Sponge this mixture on the affected area, rinse thoroughly, and allow to air dry.

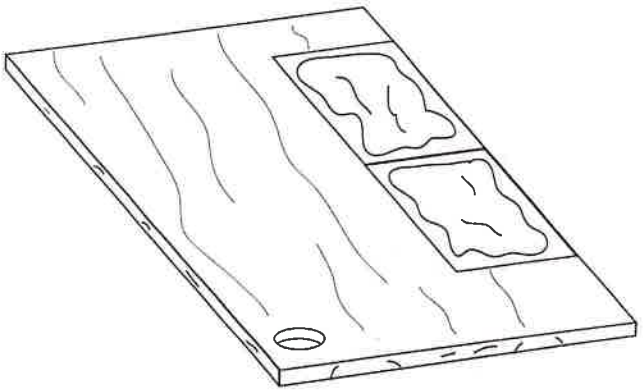


Figure 9-11. A glue trap to catch snakes can be made by attaching several rodent glue traps to a wooden board.

Snakes

A common complaint regarding wildlife around the house is the presence of snakes. Many people believe all snakes are poisonous, vile creatures. Snakes are actually quite beneficial as they help control rodent populations. Only four species of venomous snakes are found in Tennessee: copperhead (highland moccasin), cottonmouth (water moccasin), timber rattlesnake and pygmy rattlesnake. All of these are pit vipers and can be differentiated from nonvenomous snakes by three primary characteristics. All pit vipers have pits (heat sensors used for detecting warm-blooded prey in low-light conditions) located between the eye and the nostril. Pit vipers also have elliptical pupils (similar to cats) and undivided scales on the underside of the tail including the scale covering the anus (anal plate). (NOTE: The scales on the underside of the very tip of the tail of pit vipers may be divided). Nonvenomous snakes in Tennessee do not have pits or elliptical pupils (they are round), and all scales on the underside of the tail are divided from the anus to the tip (Figure 9-10).

If snakes are found frequently around your house, abundant rodents in the area are the probable cause. Diets of most snakes are comprised of rodents and insects. Snakes are typically found in areas that provide shelter for rodents, such as wood, brush and rock piles, overgrown fields, old sheds and barns. The best way to reduce snake populations around your house is to remove or clean up areas that are attractive to rodents. Vegetation should be mowed closely and all wood, brush and rock piles should be moved if near a house or other building.

Shooting or severing the head of a snake is the action taken by many people when a snake is encountered. Few people know snakes are protected wildlife species and indiscriminate killing is illegal. This should not preclude you from killing a venomous snake that poses a genuine threat; however, it is recommended that the animal be captured and removed if possible. When possible, you should consult the local TWRA wildlife officer before killing snakes.

Methods of removing snakes include glue boards and traps. Glue boards work well and are quite cost effective. Glue boards should be placed against walls for best results; this is

where snakes normally travel. Drill a hole in one corner and attach a string to allow the trap to be removed without coming into close contact with the snake (Figure 9-11). Vegetable oil is used to dissolve the glue and release the snake unharmed once the snake has been relocated.

As with other pesky animals, exclusion is the most important step in avoiding future problems with snakes. All openings into buildings 1/4 - inch or larger should be sealed by some means, such as mortar, steel wool, sheet metal or hardware cloth.

Review Questions

1. Rats can compress their body and squeeze through an opening as small as _____.
   - A. 1/4 inch diameter
   - B. 1/2 inch diameter
   - C. 1 inch diameter
   - D. 2 inches diameter

2. Norway rats have _____.
   - A. light-colored fur, large head and pointy muzzle
   - B. light-colored fur, small head and pointy muzzle
   - C. reddish-brown fur, small head and a blunt muzzle
   - D. reddish-brown fur, large head and a blunt muzzle

3. Mice 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

4. An adult _____ produces 3/4 inch long, capsule-shaped, blunt ended droppings.
   - A. pine vole
   - B. house mouse
   - C. Norway rat
   - D. roof rat

5. Roof rats live under debris and in burrows; Norway rats prefer to live high in trees and attics.
   - A. True
   - B. False

6. Rodents can be responsible for transmitting which disease?
   - A. musculitis
   - B. measles
   - C. chicken pox
   - D. salmonellosis

7. When mice infest food, the greatest loss is not what mice eat, but what is thrown out because of contamination.
   - A. True
   - B. False

8. Brodifacoum, bromadilone, chlorophacinone, diphacinone and warfarin cause rodents to die by _____.
   - A. preventing normal clotting and causing internal bleeding
   - B. causing paralysis of the nervous system
   - C. causing an excess of calcium in the blood
   - D. forming gas in the circulatory system

9. Cholecalciferal causes rodents to die by _____.
   - A. preventing normal clotting and causing internal bleeding
   - B. causing paralysis of the nervous system
   - C. causing an excess of calcium in the blood
   - D. forming gas in the circulatory system

10. Zinc phosphide causes rodents to die by _____.
   - A. preventing normal clotting and causing internal bleeding
   - B. causing paralysis of the nervous system
   - C. causing an excess of calcium in the blood
   - D. forming gas in the circulatory system

11. If rodent bait cannot be installed in a location that is inaccessible to children and non-target animals, it must be placed in tamper-resistant bait boxes.
   - A. True
   - B. False

12. The key difference in baiting mice in contrast to 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

13. Mouse traps should be placed _____.
   - A. about 6 inches away from a wall
   - B. every 50 feet
   - C. along walls, behind objects and in dark corners
   - D. in the center of infested rooms

14. 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'

15. Exclusion is the recommended method of bat control because _____.
   - A. no poisons are registered for bat control
   - B. it avoids the odor and insect problems cause by dead bats
   - C. it reduces human and pet exposure to dying bats
   - D. all of the above

16. Which is not evidence of a bat infestation?
   A. squeaking noises from ceiling and walls
   B. chirping noises from chimney
   C. a 1/4 inch opening with a dirty stain
   D. droppings on sidewalk, ledges, etc.

17. Brown or black droppings resembling instant rice grains in size and shape and composed entirely of insect parts are produced by _____.
   A. cockroaches
   B. geckos
   C. bats
   D. mice

18. Bat guano dries to form a crumbly, powdery substance that can grow a fungus. Spores from this fungus become airborne when the guano is disturbed. Inhaled spores develop into a yeast-like infection in the lungs. This produces a systemic disease called _____.
   A. fungidosis
   B. lipidosis
   C. omosis
   D. histoplasmosis

19. When working in an area where bat guano is present, one should _____.
   A. wear protective clothing
   B. wear cartridge respirator that filters 0.3 microns
   C. spray the guano with water before removing
   D. all of the above

20. Scientific evidence exists to prove ultrasonic sound emitters control bats.
   A. True
   B. False

21. Poisonous snakes in Tennessee have _____.
   A. a round pupil, a pit between the nostril and eye, and divided scales on the underside of the tail
   B. an elliptical pupil, a pit between the nostril and the eye, and undivided scales on the underside of the tail
   C. and elliptical pupil, no pit between the nostril and the eye, and undivided scales on the underside of the tail
   D. a round pupil, no pit between the nostril and the eye, and divided scales on the underside of the tail

Answers: 1. B, 2. C, 3. A, 4. C, 5. B, 6. D, 7. A, 8. A, 9. C, 10. D, 11. A, 12. A, 13. C, 14. D, 15. D, 16. B, 17. C, 18. D, 19. D, 20. B, 21. B.