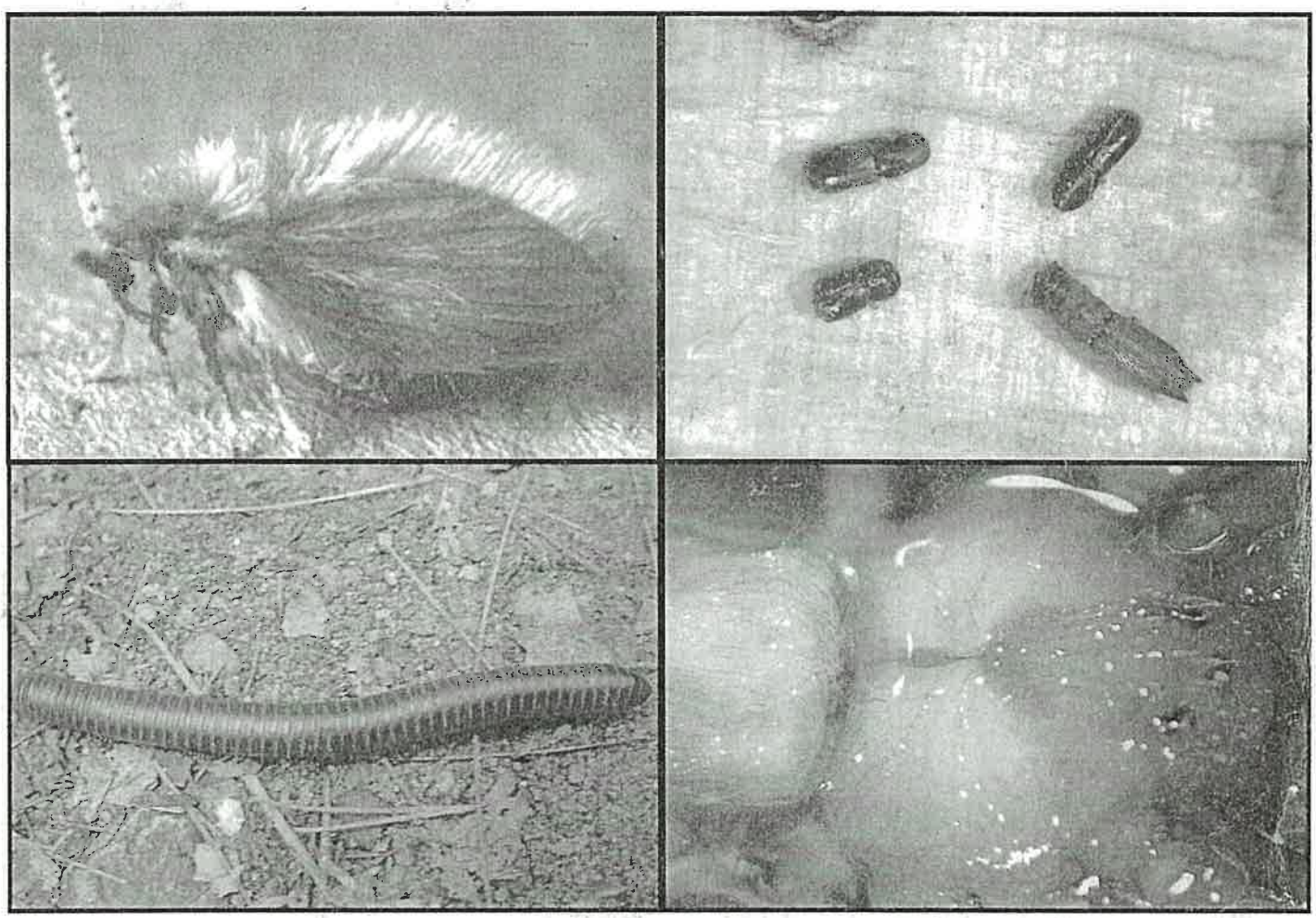
UT Extension
PB1732

Industrial, Institutional, Structural and Health Related Pest Management



Pesticide Applicator Training Manual

Certification Category: C7

Acknowledgement

The majority of this manual was modified from the following sources.

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Vail, K., H. Williams and D. Hensley. 2000. Managing Pests Around the Home. The University of Tennessee Agricultural Extension Service PB1303

Vail, K.M., G. Burgess, R. Gerhardt and C. Harper. 2002. General Pest and Rodent Control Licensing Manual (GRC). The University of Tennessee Agricultural Extension Service PB1673

Vail, K.M., G. Burgess, and C. Pless. 2002. Wood-Destroying Organisms Licensing Manual. The University of Tennessee Agricultural Extension Service PB1703

Vail, K.M., E.E. Burgess, R. Gerhardt, and C. Jones. 2002. Public Health Pest Control: Tennessee Mosquito Control Handbook Licensing Manual. The University of Tennessee Agricultural Extension Service PB1685

Corrigan, R.M. 1998. Residential, Institutional and Nonfood Industry Pest Control. Indiana Commercial Pesticide Applicator Training Manual. PPP-7a. Purdue University Cooperative Extension Service, Purdue Pesticide Programs

National Pest Control Association. 1997. Basic Training Handbook for New Structural Pest Control Service Technicians. DunnLoring, Va.

Industrial, Institutional, Structural and Health Related Pest Management

Certification Manual: C7

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How to Use This Manual

Use this manual to make effective pest management decisions that will reduce hazards to yourself, other people and the environment. If you are preparing for the **Industrial, Institutional, Structural and Health Related Pest Control** certification exam (category 7), use this book as a study guide. It is intended for use in combination with the **Core Manual,** ***Applying Pesticides Correctly: A Guide for Private and Commercial Applicators.*** Both this category 7 certification manual and the Core manual are available in printed form through University of Tennessee Extension. In addition, these manuals can be viewed at the following Web site: http://eppserver.ag.utk.edu/psep/secondlevel/materials.htm.

When you apply pesticides 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 handle or apply pesticides in any type of residential, industrial, or institutional situation.

In chapters pertaining to specific pests, tables may be provided to summarize pest identification, damage, behavior, biology and management methods.

Ten study questions are provided at the end of each chapter to give you an example of the type of questions to expect on the exam. These study questions do not cover all of the subject matter that will be tested.

The references in the credits and 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 University of Tennessee Extension offices in Tennessee counties.

Table of Contents

Pesticide fire dry powder

Preface

Many living organisms can be a pest 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 illnesses. 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.

The current proposed rule for certification category 7: Industrial, Institutional, Structural and Health Related Pest Control is as follows: This category includes commercial applicators using or supervising the use of pesticides in, on, around food handling establishments, human dwellings, institutions, such as schools and hospitals, industrial establishments, including warehouses and grain elevators, and any other structures and adjacent area, public (excluding mosquito treatment on public land and public waters) or private; and for the protection of stored, processed, or manufactured products.

Certification category 7 is often thought of as Urban Pest Management. Urban pest management involves managing pests found in and around structures including pests of companion animals. The "urban" in this definition is misleading because urban pest management is performed in the suburbs as well as rural areas.

Over the past dozen years or so, "urban pest control" has changed dramatically. Pest management has evolved from spraying pests in a home to "monitoring and managing urban pests." Sprayers are being replaced with insect trap monitors and liquid insecticides are giving way to baits and bait guns. New terminology in urban pest management is also emerging. Low-impact pesticides, nonchemical control, pest-proofing, situation analysis, prescription applications, precision targeting and pheromone traps are just a few new terms in the working vocabulary of urban pest management professionals.

This manual presents information on the basics of urban pest management.

Chapter 1 Federal and State Pesticide Laws and Regulations

Industrial, Institutional, Structural and Health Related Pest Control

This category includes commercial applicators using or supervising the use of restricted-use pesticides in, on, around food handling establishments, human dwellings, institutions, such as schools and hospitals, industrial establishments, including warehouses and grain elevators, and other structure and adjacent area, public (excluding mosquito treatment on public land and public waters) or private; and for the protection of stored, processed, or manufactured products.

U.S. Environmental Protection Agency (EPA)

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. Each state and Indian 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.

Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)

In 1947, Congress passed the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) which required federal registration of pesticides shipped in interstate commerce. Under the 1947 FIFRA, registered pesticides could be used by almost anyone for any purpose, and in any way, because that law did not address itself to pesticide use.

Federal Environmental Pesticide Control Act (FEPCA).

In 1972, Congress amended the FIFRA to add key regulatory mechanisms. This legislation is known as the Federal Environmental Pesticide Control Act, FEPCA. Among other things, these regulations (1) prohibit use of any registered pesticide in a manner inconsistent with label instructions; (2) require that pesticides be classified for general or restricted-use; (3) provide that pesticides in the restricted category may be used only by or under the direct supervision of certified applicators, or under such other regulatory restrictions as the EPA administrator may require; (4) establish general categories of certified applicators: private applicator and commercial applicator; (5) provide penalties (fines and jail terms) for violations of FIFRA; and (6) provide states the authority to regulate the sale or use of any federally registered pesticides in that state. The amended FIFRA was fully implemented in October 1977. A discussion of Tennessee certification will be covered under the state law.

By regulation, the EPA set minimum standards of competency for certification of pesticide applicators. This regulation, 40CFR171 "Certification of Pesticide Applicators," allows states and Indian tribes with EPA-approved plans to administer certification programs within their boundaries. Certification is proof that an applicator knows the correct and safe way to apply restricted-use pesticides.

Classification of Pesticides. Manufacturers must register every pesticide with the EPA. All pesticides must be classified by EPA either as general- or restricted-use. These are defined under the state law.

- Label Directions. An applicator may not use any pesticide in a manner not permitted by the product's label. A pesticide may be applied only on plants, animals or sites specified in the directions for use. You may not use higher dosages, higher concentrations or more frequent applications. You must follow directions for use, safety, mixing, diluting, storage and disposal.

Penalties. *Civil Penalties* – In general, any commercial applicator who violates any provision of FIFRA may be assessed a penalty of not more than $5,000 for each offense ($1,000 for private applicators). Before the agency imposes a fine, you have the right to ask for a hearing.

Criminal Penalties – In general, any applicator who knowingly violates any provision of FIFRA shall be fined not more than $25,000 or one year in prison ($1,000 and/or 30 days in prison for private applicators).

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

The following pages will cover portions of the 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, who will henceforth be referred to as TDA or the State Department.

Under this act, 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. The definition of a pesticide includes, but is not limited to, insecticides, fungicides, bactericides, herbicides, desiccants, defoliants, plant regulators and nematocides.

Tennessee Department of Agriculture (TDA). 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 insures 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).

Certification. The commissioner of agriculture has the authority to authorize one to use, supervise the use, buy or sell restricted-use pesticides, in the process called certification.

Pesticide Classification. Registered pesticides are classified by federal and state laws as either general-use (unclassified) or restricted-use.

General-use pesticides are those that will not ordinarily cause unreasonable adverse effects on the user or the environment when used in accordance with label instructions. These pesticides are available to the general public.

Restricted-use pesticides are defined as those that may cause adverse effects on the environment and/or the applicator, unless subject to additional regulatory restrictions. They are generally available only to certified applicators.

Pesticide Applicator Classification. Applicators of restricted-use pesticides must be certified as private applicators or commercial applicators.

A *private applicator* is a farmer, rancher, orchardist, nursery, producer, greenhouse operator, etc., who uses or supervises the use of restricted pesticides to produce an agricultural commodity on property owned or rented by the applicator or his/her employer or (if applied without compensation other than trading of personal services between producers of agricultural commodities) on the property of another person.

Commercial applicators are those who use or supervise the use of restricted pesticides on any property other than as provided by the definition of "private applicator." Commercial pesticide applicators are certified to work in certain categories.

Commercial applicator certification may be issued in the following *categories*: C01 - Agriculture, C02 - Forest Pest Control, C03 - Ornamental and Turf, C04 - Seed Treatment, C05 - Aquatic Pest Control, C06 - Right-Of Way, C07 - Industrial, Institutional, Structural & Health Related Pest Control, C08 - Public Health Pest 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.

A *Licensed Pest Control Operator* is an individual engaged in commercial pest control with a chartered company and charges a fee for their service. Or, they are engaged in the same with a non-chartered company or establishment, such as, a food processing plant, prison or school. There must be a licensed pest control operator for each licensing category in which a business operates. The licensed applicator will also supervise the certified technicians, registered solicitors, salespersons and other licensees. In addition to passing the exams to be certified as a commercial applicator and licensed, they must be bonded, insured and have a business charter for each office or branch office. A license and charter may be obtained from the State Department for a fee.

Training Opportunities for Commercial Applicators. Training sessions for Commercial Applicators are held periodically by The University of Tennessee, Extension for those needing to become certified. Scheduled training sessions include information on both general standards and the particular category. This training is usually offered the first Wednesday of each month at UT Knoxville (Rm. 156 - 157 Plant Biotech Bldg., UT Ag Campus) and down-linked by interactive television (ITV) to Johnson City (East TN State University), Chattanooga (UT), Nashville (UT Extension Central Region Office, Ellington Agricultural Center) and Jackson (UT West Tennessee Research & Education Center). The registration fee for training is $25 for the "Core" and $10 for each Commercial Applicator category that may be offered.

Study materials have been developed by the faculty at the University of Tennessee and are available for purchase to study for an exam. An order form, Form 818 is available from the Pesticide Coordinator's office at UT or at the UT PSEP web site http://eppserver.ag.utk.edu/psep/psep.htm. The registration fee may be paid and study material purchased at the following address:

Pesticide Safety Education Program (PSEP)
University of Tennessee
Department of Entomology & Plant Pathology
Rm 205 Ellington Plant Sciences
2431 Joe Johnson Dr.
Knoxville, TN 37996-4560
Phone: 865-974-7138 or e-mail: gburgess1@utk.edu

Exam Opportunities for Commercial Applicators. Written examinations are used to determine the competence of commercial applicators. Part of the test includes general standards which all commercial applicators must know. These standards include a practical knowledge of the principles and practices of pest control and the safe use of pesticides. The remainder of the test is related to the particular category. The certification exams are given by the Tennessee Department of Agriculture. The exam fee for a commercial category is $15, and must be prepaid two weeks in advance of the exam date. Send your check or money order to the following address:

Certification and Licensing Section
Tennessee Department of Agriculture
Box 40627, Melrose Station
Nashville, TN 37204.
Phone: 615-837-5148
E-mail: maryborthick@state.tn.us

TDA will then notify the applicant of the date and location to take the exam(s). TDA offers the certification exams in Nashville every Tuesday, Wednesday and Thursday at 8:30 and 1:30 p.m. at the Bruer Building, Ellington Agricultural Center. Phone 615-837-5148. In Jackson, TDA offers the exams every Tuesday, Wednesday and Thursday at 8:30 am in Room 237 at the West Tennessee Research and Education Center. Phone 731-423-5657. In Memphis, TDA offers the exams every Tuesday, Wednesday and Thursday at 9:00 am and 1:30 p.m. at the Shelby County Extension Office in Memphis, Tennessee. Phone 901-543-6981. There are other county Extension offices that offer the exams.

Recertification of Commercial Applicators. A commercial applicator's certification period only lasts for three years. Everyone's certification expires on the same date, October 21, 2008.

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 in the following areas in the individual's certification category:

- Pests
- Pest control
- Worker Protection Standards (WPS)
- Pesticides
- Pesticide safety
- Integrated Pest Management (IPM)
- Environmental issues (water quality, endangered species, etc.)

Safety, environmental issues, IPM, laws and regulations apply to all categories for assignment of points. Points are not assigned to individual videos but to programs.

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 the someone in the Certification and Licensing Section, TDA, assigns points for industry programs.

The following are additional guidelines with regard to the point system:

- In-house points will be limited to 50% of your total point requirement.
- No points may be carried over to another year or another certification period.
- All training must be submitted to the office no later than 30 days prior to the date of the training session.
- Those approving certification training reserve the right not to grant points for training submitted late.
- An announcement of the training date, time, place and points assigned per category will be placed on the Tennessee Department of Agriculture's and the University of Tennessee, Extension, Department of Entomology and Plant Pathology (EPP) web sites. EPP Pesticide Safety Education Program (PSEP) Web site is located at http://eppserver.ag.utk.edu/psep/psep.htm

The TDA web site is http://www.tennessee.gov/agriculture/regulate.

- The sponsors must agree to permit representatives from the Department of Agriculture and/or UT Department of Entomology and Plant Pathology to attend and monitor training sessions without registration fees or costs.
- After attending a training session the Tennessee Department of Agriculture or the University of Tennessee, Extension, upon consultation between these two agencies, training and point assignment may be re-evaluated. Point assignment may be withdrawn or revised as deemed necessary.

Programs submitted should include the following information:

- Meeting title
- Sponsor
- Meeting date(s)
- Location(s)
- Chairperson's name, address and phone
- In-house or external training
- Category applying for points
- List of topics
- Speakers (with their titles)
- Length of each topic to be presented

A form from The University Tennessee, Department of Entomology and Plant Pathology, E&PP Info #82, *Tennessee Pesticide Recertification Application for Points*, is available for this purpose.

The number of points one must accumulate over a three year period, from October 22, 2005 until October 21, 2008 for example, are as follows:

Categories	Suggested No. of Points / Year	No. of Points / Three Years
C07, Gen. Household and Structural	10	30
C01, Agricultural Pest Control C03, Ornamental & Turf C06, Right-of-Way C08, Public Health C10, Demonstration, Research & Regulatory C12, Dealer	6	18
C02, Forest Pest Control C04, Seed Treatment C05, Aquatic Pest Control	4	12
C11, Wood Preservatives C13, Antifouling Marine Paint C14, Microbial Pest Control C16, Sewer Line Treatment	3	9

The points required may be prorated, depending on when one is certified. If the required points are not earned each year, one may have to take a recertification exam in the third year.

It is your responsibility to contact the Certification and Licensing Supervisor with TDA in Nashville if you have a name or address change. If correspondence goes back to their office because of an incorrect address, applicators will not receive additional mailings until the correct address information is corrected.

Additional information on the point requirement for each category may be found in SP363-D, "Tennessee Commercial Applicator Recertification Point System."

Annual Meetings. A list of annual meetings where recertification points may be earned is found in E&PP Info. 375. This may be obtained from the Pesticide Coordinator's office. See address and telephone number on a previous page.

Current Workshops/Seminars. The annual meetings and upcoming meetings (current workshops/seminars) may be found on the Department of Entomology and Plant Pathology (EPP) web site at http://eppserver.ag.utk.edu/psep/psep.htm or directly from EPP, at the previously given address or telephone number. Meetings may also be found at the TDA web site, http://www.tennessee.gov/agriculture/regulate

A $5 fee is required for your new certification card, if enough points are earned in the designated time period.

Charter. Each person, firm or corporation who wishes to engage in business (custom application) as a commercial pest control operator must secure a charter from TDA in the category or categories in which they intend to do business. "Custom application" is defined as the application of a pesticide for a fee, and also includes the solicitation of such services. It does not matter if the pesticide is restricted-use or general-use. If, you offer to apply a pesticide for a fee you must be associated with a chartered company. A charter is required for each office and branch office. Before a charter may be obtained, one must show proof of licensing, bonding and insurance. When working in the Wood-Destroying Organisms (WDO) category, one must have errors and omissions insurance in addition to liability insurance.

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.

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. A pest control technician applying pesticides under the supervision of a licensed pest control operator has 90 days from the date of his/her employment to become certified as a commercial applicator. If a technician is not certified during the 90-day period, he/she can only continue to apply pesticides in the presence of a licensed operator.

For more information on the laws and regulations regarding licensing and Commercial Pest Control Operators see PB 714, *Summary of the Federal and State Pesticide Laws and Regulations* or TDA's publication, *Laws and Regulations Governing Pest Control Operations and Applications of Restricted Use Pesticides.*

Training Opportunities for License Categories. Training is offered for those taking the Horticulture, Lawn and Turf (HLT), Public Health Mosquito Control (PHMC), General Pest and Rodent Control (GRC) and Wood Destroying Organism (WDO) licensing exams. The training is offered in Nashville on Monday and Tuesday before the licensing exams on Tuesday and Wednesday during the first, second or third week of each quarter. The training begins on Monday at 12:00 noon for HLT and 4:45 for PHMC and on Tuesday at 8:30 a.m. for GRC and 12:30 p.m. for WDO at the Extension District Office Conference Room in Nashville.

Exam Opportunities for License Applicators. Licensing exams are given once a quarter by the State Department at the Ellington Auditorium in Nashville. To take an exam, you must send an application to the State Department a month before the exams are offered (must be postmarked by the 10th of the month preceding the month of the exam). The application for initial examination or reexamination must be accompanied by an examination fee of $150 for each category in which the examination/reexamination is requested.

After the State Department examines your licensing application, all qualified applicants will be notified of the time and place of the examination. If you pass the exam, the license must be renewed by January 1, every two years. A - K are renewed on even years and L - Z on odd years.

Denial, Suspension or Revocation of Certificate. If a 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 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.

Record Keeping. All commercial applicators and commercial pest control operators must keep records of both

restricted and general use pesticides for two years. These must be made available on demand to the Commissioner of Agriculture, or his/her designee. These records must show (for each application)

- The pesticide used
- The target pest
- The crop, plant, house, business or building the pesticide is applied on or to, and the location
- The dosage rate
- The percentage of mixed-use dilution
- The landowner, agent or other person employing such applicator
- The date of service
- 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. This form and record keeping software may be obtained from the UT Pesticide Coordinator's office at the address given on a previous page. A copy may be downloaded from 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 it 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.

Federal EPA Registration. The vast majority of pesticides are registered under "FIFRA Section 3" status, a federal label. These products have been reviewed and approved for label use by the EPA, and the registrant then registers the material with the states.

Special Local Needs Registration. A "24-C," is also known as a "Special Local Need" (SLN) registration. It is an application from a registrant to allow the use of a pesticide on an object for which it is not presently federally labeled. In the case of food, a tolerance must have been established. 24-C applicants must submit a completed federal Special Local Need form (EPA form 8570-25), a copy of the proposed label, the application fee of $250, and any support material they deem necessary. In general, approvals are for 5 years.

Emergency Exemptions from Registration. The registration term "*Section 18*" is really more of an exemption to the registration process. With rare exception a Section 18, an emergency or crisis exemption, is pursued to allow the use of a pesticide on a food crop for which there is not an established tolerance, but there is an established tolerance for at least one other food crop.

Experimental Use Permit, EUP. An EUP is, as its name implies, a permit from the EPA to test a pesticide under controlled conditions. The EPA grants the permit, and the state department monitoring staff inspects use sites at random. The state neither reviews or approves an EUP. But, the state accepts the EPA's decision, and issues no notice of acceptance.

Powers of 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 pesticides. And, this lot of pesticides 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.

Endangered Species Act

This Federal law was designed to protect plant and animal species that are in danger of extinction. The EPA, in cooperation with other Federal, state and county agencies, has established limitations on the use of certain pesticides in specific areas known to harbor endangered species. Prior to making any pesticide application, the user must determine that endangered species are not located on or immediately adjacent to the site to be treated. If in doubt, the user should contact the regional U.S. Fish and Wildlife Service Office, or the state fish and game office.

Federal Hazardous Materials Transportation Law (FHMTL)

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 have a rated capacity of less than 1,000 gallons and 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 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 (OSHA)

The OSHA 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.

Employers must keep records of all work-related deaths, injuries and illnesses and make periodic reports.

Hazard Communication Standard (HCS). The OSHA HCS (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 HCS, 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 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.

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 as follows:

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 which do not generate more than 1 kg of acutely hazardous waste (or 100 kg of spill clean-up debris) during the same month, an which 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 CERCLA.

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 CERCLA direct the US DOT to list and regulate hazardous substances. In compliance, DOT has listed the hazardous substances in the Appendix to the Hazardous Materials Table (49 CFR 172.101), and requires special markings and shipping paper entries to alert the carrier that he/she is transporting them.

Note: For more detailed information on the Tennessee laws and regulations related to pesticides see the following publication:

"Laws and Regulations Governing Pest Control Operators and Applicators of Restricted Use Pesticides"

Review Questions:

1. What agency is responsible for the enforcement of federal pesticide laws and regulations?
   A. UT
   B. TDA
   C. USDA
   D. EPA

2. Which law requires federal registration of pesticides shipped in interstate commerce?
   A. TIFRA
   B. FIFRA
   C. FEPCA
   D. TAPA

3. Which law prohibits the use of any registered pesticide in a manner inconsistent with label directions?
   A. TAPA
   B. FEPCA
   C. USDA
   D. RCRA

4. Any Commercial Applicator who violates any provision of FIFRA may be assessed a civil penalty of not more than?
   A. $5,000
   B. $10,000
   C. $15,000
   D. $20,000

5. Which agency is responsible for the protection of the health, safety and welfare of pest control employees and the general public from the hazards of pesticide use in Tennessee?
   A. USDA
   B. DOT
   C. TDA
   D. TDOT

6. The TDA certification and enforcement functions are coordinated primarily through what division of TDA?
   A. Division of Plant Industries
   B. Regulatory Services Division
   C. Fishery and Wildlife
   D. Pesticide Regulatory Division

7. Pesticides that may cause adverse effects on the environment and/or the applicator, unless subject to additional regulatory restrictions are classified as?
   A. General-use pesticides
   B. Unclassified
   C. Restricted-use pesticides
   D. Commercial-use pesticides

8. A certification period lasts for how many years?
   A. 5 years
   B. 4 years
   C. 3 years
   D. 2 years

9. One may earn up to what percentage in-house points in the recertification program?
   A. 10%
   B. 80%
   C. 30%
   D. 50%

10. How many recertification points are required for Category 7 in a 3 year period?
   A. 30
   B. 6
   C. 10
   D. 4

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

Chapter 2 Implementing Urban Integrated Pest Management Programs

It is important to recognize that chemicals should not necessarily be the first choice for solving a pest problem. Urban integrated pest management (IPM) is a process that utilizes periodic monitoring and/or inspections to determine if and what type of treatment is needed to keep populations below intolerable damage or annoyance thresholds. The resulting data form the basis for responsible pest control decisions. Urban IPM includes any combination of the control methods.

Educational programs are needed to inform pest control decision-makers on the merits of IPM: IPM can lessen or even eliminate the need for certain pesticide applications and can reduce pesticide exposure to people, property and the environment by selecting target-specific, low-impact products in cases where chemical applications are necessary. Applications should not be made according to a predetermined schedule; they should be made only when and where monitoring or inspection has indicated that the pest will cause unacceptable economic, medical or aesthetic problems. IPM programs must be environmentally, socially and economically compatible to meet public expectations.

An important point to realize is that IPM is much more than simply applying a pesticide to correct a pest problem; and it is much more effective, as well. This chapter addresses the steps required to implement IPM on-the-job.

Integrated Pest Management

In many ways, pest management professionals have incorporated IPM into their pest management strategies for many years. However, it is important to understand there are four steps that should be taken in sequence for a program to be classified as integrated pest management:

1. Inspection
2. Determination of pest thresholds
3. Application of pest management procedures
4. Evaluation: monitoring of pest populations and the management program, and repeating measures as needed.

Following these steps, pesticide applications are kept to a minimum and, when used, have minimal impact on the environment.

Step. 1 Inspection

It is important to note that in steps 2-4 of an IPM program, a decision must be made as to how pest management is conducted. This decision is always based on the results of the inspection.

The inspection is the first and most important phase of any pest management operation; as such, it involves much more than simply looking for pests or signs of their presence, or for the damage they have caused. Professional inspections begin with looking, but it is in the seeing and analyzing each situation that the pest management professional gains insight into making prudent pest management decisions. It is emphasized that proper inspections affect a professionals' management strategies, regardless of whether chemical or nonchemical approaches are contemplated. When the use of pesticides is being considered, a good inspection can reveal specific areas to be targeted for application, thus reducing the likelihood of chemicals being applied where they are not needed. Without a proper inspection, a pest management professional cannot be sure of the severity of a pest population or its distribution within a building; as a consequence, there is a tendency to rely on a broad range pesticide application to compensate for the lack of knowledge specific to the pest problem.

It is the responsibility of every pesticide applicator NOT to rely on a "pesticide crutch" for pest management. Inspection is the key to avoiding the crutch and designing smart, effective IPM programs.

Objectives of the inspection:

1. Confirm pest identity and presence
2. Identify the location and source of the pest problem
3. Determine the extent of the pest infestation
4. Analyze the environmental, regulatory and clientele factors that may limit a pest management strategy.

Confirm pest identity and presence. This is the most obvious objective of a pest management inspection: Does a pest problem exist and, if so, does the pest need to be identified to species? Usually, a professional responding to a pest problem already knows the general identity of the pest. For example, the school kitchen in town has reported cockroaches; a home has termites; the courthouse has pigeons and an office complex has ants. But the identity of the pest must always be confirmed, and this requires sampling the pest, at the account, for positive identification.

Although pest identification is one of the most basic elements of pest management, mistakes are common in dealing with many urban pests - especially those that resemble others in appearance. For example, are the ants at the office complex fire ants or Pharaoh ants? Are the birds observed from ground level pigeons or are they really mourning doves? Are the school's cockroaches American or German cockroaches?

There are many additional examples of look-alikes, but the important point is: The consequences of misidentification vary from expensive callbacks to lawsuits by angry clients.

If the pest cannot be identified to species (or as close to species as needed to establish a management program) on the job or back at the shop, the pest should be sent to a pest specialist for species confirmation. Many resources are available to aid identification (see Appendix). Also, your local county Extension agent can submit a specimen to the Plant and Pest Diagnostic Lab in Nashville. Many agents now have the capability to send a digital image to the Diagnostic Center. Distance Diagnosis through the Digital Imaging System of the University of Tennessee Extension will allow text-based information and digital images to be submitted from county Extension offices for rapid diagnosis by resource professionals at the Plant and Pest Diagnostic Center, in Nashville. County Extension faculty are trained to submit plant disease or pest images and information using digital cameras, microscopes, computers and the internet.

Identify the location and source of the pest problem. Because of the pressure due to time constraints and production quotas, pest management professionals may sometimes be tempted to treat only the location where pests are discovered. But in many cases, the source of an infestation must be identified and eliminated for effective control. Taking the time to assess the entire situation initially reduces the need for repeated and unnecessary pesticide applications.

Determine the extent of the pest infestation. A good inspection reveals whether a pest problem is confined to a certain area or exists throughout a structure. In addition, the inspection should extend to furniture, equipment, etc. in an effort to determine the scope of the infestation.

Outdoors, the inspector should conclude whether there is an infestation beyond the property line that might favor migration of the pest back to the site being treated. Monitoring programs can help in this regard and provide valuable data for objectives 1 and 2.

Analyze the environmental, regulatory and clientele factors that may limit a pest management strategy. Many environmental factors affect pest management strategies: heat, moisture, air currents, dust, food sources, clutter and poor sanitation (indoors and out). For instance, if excessive moisture exists in a pest harborage area, pesticide applications to that area will not be very effective. Similarly, placing glue traps in excessively dusty areas is a waste of time and materials. Analyzing the environmental factors during the inspection helps determine which pesticide formulation or monitoring device should be used.

Pest management professionals must analyze clientele factors, on-site as they work; that is, they must be aware of the surroundings and adjust accordingly.

Examples:

- A customer's home has mice. The customer doesn't object to the use of pesticides to rid the mice, but the inspector observes that the customer's dogs and cats have free reign of the entire home. Based on this observation, the use of baits is ruled out.
- Consider a large office complex with a fly problem. During the pest management inspection, it is noted that one office in the complex has an aquarium; therefore, nonchemical control methods should be used in that particular office in order to protect the fish. If chemical control were absolutely necessary, special precautions would have to be taken.

Inspection Equipment

Proper equipment is essential in conducting quality pest management inspections. The professional must have insight into the pests' world and be equipped to access various structural, furniture, and equipment voids that they might inhabit. Even the most talented inspector cannot perform quality inspection without the proper equipment; and a sound pest management strategy cannot be described in the absence of a quality inspection.

Table 2-1 provides a list of recommended inspection equipment. Depending on the account (residential vs. commercial) and the situation, inspection equipment needs will vary. In some cases, a strong flashlight might be the only equipment needed; but more often, several tools are necessary to perform quality in-depth inspection. Wood-destroying organism inspections may be augmented with a moisture meter, canine termite detector (termite sniffing dog), acoustic emissions detector, thermal imaging, or microwave-based detection equipment.

Inspection Techniques

Beyond the basics, performing a good pest management inspections is an art. Following are a few examples of general inspection techniques for both residential and commercial accounts.

Identify Warm and Humid Areas. Many urban pests require and seek warmth, moist, dark and humid conditions. A good inspection technique is to first identify areas within a structure that offer such a tropical environment and inspect these areas first.

Gain Access and Inspect All Areas. There are no specific rules for an inspector regarding where and where not to look. Pests do not respect locked doors or restricted area signs; therefore, an inspector must inspect everywhere. Locked doors and private rooms can hide problems that impact IPM strategies. Any rooms and areas to which access is denied should be clearly noted on a report form and signed by the client.

In commercial accounts, equipment must be accessible for inspection because cockroaches, grain pests, flies and many other pests may hide and proliferate within the motor or other working elements.

Identify Clutter. A strong association exists between pests and clutter. Boxes, packages, drawers and general debris must be moved so they can be inspected underneath and behind. This is especially important for items stored (as they often are) on the floor, directly against a wall.

Monitor for Pests. Monitoring, as part of an inspection, is one of the most critical and valuable component of a true IPM program. In fact, monitoring is one of the most distinguishable aspects that separate IPM programs from standard pest management programs.

Monitoring can guide the entire IPM program. Its purpose is to confirm the presence of a pest and/or to determine its populations level. In conjunction with other components

Essential Equipment	Notes and Comments
Utility Belt/ Pouch	Holds equipment. Facilitates the use of inspection equipment. Presents a professional image.
Quality Flashlight and Holder	Must provide bright light and be of heavy-duty quality. Have extra batteries, bulbs and spare light. Some accounts require a spark-proof light. Holder minimizes loss and breakage. Looks professional.
Access Tools	Screwdrivers or utility knives, spatulas, drills, carpet tack removers.
Trap monitors	Many different brands. Small sizes for monitoring. Pheromone traps for formal stored product pest monitoring programs.
Ladders	Do not rely on customer to provide. Many pests are above reach.
Flushing agent	Helpful for cockroach, ant and other pests that hide in cracks and crevices. Must not be over applied. Must not be used in sensitive accounts. Cans of forced air are acceptable in most environments.
Coveralls	Protects clothing for entire inspection. Facilitates working in dirty environments.
Knee Pads	Protect knees. Repeated kneeling is essential for most inspections.
Bump Cap	Protects head. Presents professional image.
Inspection Forms, Floor Plans and Clipboard	Forms list important areas to be inspected. Floor plans help professionals orient themselves in complex buildings and analyze pest movement and distribution. Clipboard protects and organizes information and presents professional appearance.
Inspection Mirror	Provides visual access beneath low counters, equipment and into suspended ceilings, etc. Polished metal mirrors only.
Additional Equipment	
Hand Lens	On-the-spot identification.
Collection Vials	Verification of collected specimens is an important service to clients. Labeled vials present a professional collection method as compared to envelopes or other temporary means.
Safety Equipment	
Safety Glasses and Ear Plugs	As requested by client.
Respirator	Determined by work site and conditions.
Hair and Beard Nets	As required by client.

Table 2-1. Equipment for pest management specialists.

of the inspection, monitoring is critical in answering these questions:

- Is the infestation minor, moderate or severe?
- Has the pest management program eliminated all the pests?
- Have new pests been introduced into the account?

New technology has provided various monitoring tools (pheromone traps, live traps, etc.) as well as new techniques and programs for using them. Sticky traps, for example, are available in many different models. In residences, they can be placed in attics, garages, and crawl spaces as well as along sill plates in basements. Sticky trap monitoring provides a complete year round pest profile of a residential account.

Pantry pests pheromone traps can be installed in kitchens cabinets, and clothes moth pheromone traps can be placed in clothes closets to alert the homeowner to the presence of moths which otherwise might have caused damage to expensive woolen goods.

In commercial accounts such as restaurants and supermarkets, the species-specific pheromone traps are critical elements

of an IPM program. Similarly, in school and hospital kitchens and in office complexes, sticky traps are essential in monitoring for German cockroaches. It is hard to imaging either a residential or a commercial account where a pest management professional would not need to use trap monitors to perform a quality inspection. Monitoring devices are essential to effective, long-term service to an account.

Some pest problems might require unique types of monitoring programs; but generally several different pests can be monitored using the same tools and techniques. Because monitoring is so important, note the following examples of on-the-job monitoring programs:

- Installing 25-35 cockroach sticky traps in a restaurant to monitor the success of a pest management program or to detect new infestations from incoming supplies.
- Installing yellowjacket traps around the perimeter of a school in June to monitor the presence and abundance of yellowjackets that might affect students when school resumes in August.
- Conducting a one-hour, evening inspection of the rat activity in a city alleyway before a management program is implemented and after its completion.
- Installing pheromone traps in the back of a supermarket to monitor for the possible presence of grain moths in bird seed, dog food, or breakfast cereals.
- Conducting a 15-minute, evening inspection of the main carpenter ant trail leading into a house before a baiting program is begun and after its completion.

Monitoring assists the pest management professional in deciding whether or not action is justified and, if so, what type of action is needed. As an example, consider the many cases of unjustified pesticide application that occur on a regular basis in and around buildings. Monitoring can demonstrate to a client that pesticides need not be applied; that is, if no pests area located during monitoring, there is no justification for pesticide application. On the other hand, clients who oppose the use of chemicals might require proof that a pest is present before they are willing to allow pesticide use; and monitoring is the technique that will demonstrate the pest's presence and justify the treatment prescribed.

Utilizing Angles of Perspective. A pest management professional should examine an account from all the perspectives when conducting an inspection: ground level, eye level and high level. At ground level, the inspector has to get on hands and knees or lie on the floor. At eye level, they must look up, down, ahead and behind. And they must look down from a high vantage point accessible by ladder or some other means. Also, an inspector should think three-dimensional, considering what lies beyond a wall or within a piece of equipment.

Inspect from the Lines Perspective. Insect and rodent pests tend to select paths of least resistance during their daily travels. Thus, they often utilize the various structural and utility lines found within buildings. For example, insects and rodents, while traveling from their nests to their feeding areas, often travel along plumbing lines, electrical lines, duct channels, exterior utility lines, food processing conduits and equipment lines. They often mark these travel paths with body odors and pheromones which enable them to relocate and reuse them. Over time, these lines become their daily highways.

These paths and the area they lead to should always be inspected for evidence of pests. It is also important to inspect areas where various lines may terminate: junction boxes, electrical switch panels, wall exteriors, etc.

Perform Nighttime Inspections. Cockroaches, rodents, carpenter ants, silverfish, urban wildlife and many other urban pests area active at night, so much can be learned by inspecting a premises at dusk or early evening. A nighttime inspection may reveal hidden or otherwise undetectable harborage that, unless treated, could be the key source of a pest problem.

Use Pest-Sighting Log Forms and Interview Employees of Commercial Accounts. In large, complex commercial accounts (hospitals, high-rise condominiums, schools, etc.) the employees are among the best sources of information regarding areas of pest activity. The custodial and kitchen employees, for example, may know of a cockroach harborage that has been hidden by new paneling or equipment; or they may have watched an ant disappear into a tiny opening which might be overlooked by even the best inspector.

Pest sighting forms are valuable tools for the pest management professional. Providing them to the client allows the inspector to follow up and discuss pests sightings, thus rendering the pest management program more effective and efficient. The date and exact location of each pest sighting should be entered and the name of the person who sighted each pest should be logged.

Consult Building Plans. Another valuable inspection technique for large commercial accounts is to utilize building plans. These plans enable the inspector to visualize floors and rooms, above, below, and on all sides of problem areas. Building plans also illustrate the layout of the building, utility lines, heating and cooling ducts, shaft connections, pipe chases and so on. The plans help to pinpoint warm, humid areas, thus aiding in the identification of high activity areas where certain insects such as Pharaoh ants, cockroaches, silverfish and others thrive.

Building plans can also reveal potential entry points into buildings and possible migration paths of pests from one part of a building to another. Finally, building plans can serve as a checklist to organize large pest management programs and help ensure that all the pertinent areas of the building receive attention. Building plans are valuable inspection aids; professionals find them worthwhile, even if they take time and effort to obtain. They can be used throughout the entire pest management operation.

Reports and Report Forms

In customer service industries such as pest management, the job is not done until the paperwork is completed. Reporting the results of an IPM inspection is mandatory. Inspection reports help protect both the professional and the client and are critically important in our litigious society.

An inspection form for standard inspections should list, as a minimum, the specific pest present, the extent of the infestation, the control tools and chemicals to be used and all the structural deficiencies requiring corrective action.

For complex inspections involving large buildings or areas, inspection forms that include checklists for each specific location are helpful; the checklists help to assure that the inspector

does not miss any pertinent areas. But even so, checklists must be used with caution; the inspector must not get caught up in completing the checklist and overlook something important that is not listed.

Some professionals prefer to start with a blank piece of paper and record their findings, referring to an inspection form only after taking notes on a particular area from their own perspective. Although there are many types of inspection forms used in pest management industry, there is no one form that meets all needs. Examples of some forms and guidelines are provided in Tables 2-2 and 2-3, but it is important to recognize that no form can replace the good judgement of a thorough, experienced inspector.

Residential Inspections. Generally, residential accounts (private homes and apartments) require less sophisticated inspection equipment and techniques than do commercial accounts. Still, several points are important. Table 2-2 provides a list of general questions for residential inspections. Answers recorded by inspectors combine to a form a comprehensive profile of the home with respect to conditions that could lead to pest infestation (other than termites and other wood-destroying organisms). However, Table 2-2 is but one example; many pest management companies design their own inspection forms.

Commercial Building Inspection. Relative to pest management, commercial and residential buildings differ. Commercial buildings are structurally complex and are subject to greater pest pressures. Consider a restaurant, school, hospital, pet store, or supermarket with incoming supplies, constant operation, people flow, pesticide restrictions, complex design, surrounding industrial areas and buildings, intense operating conditions, etc. Greater attention to more details is typically required for commercial building pest management inspections. In most cases, pest management companies have customized inspection guides for commercial accounts. See Table 2-3 for an example.

Step 2. Determination of Pest Thresholds

One of the most interesting and sometimes confusing aspects of urban pest management is the concept of the pest threshold - also called pest tolerance level. The pest threshold in urban situations is simply the point of incidence (rate and range of occurrence) beyond which people are not willing to tolerate the pest presence.

In reality, most prefer not to share their environment with any number of pests, that is, they have a threshold of zero. While zero thresholds are possible and realistic for certain accounts, they may be neither possible nor economically feasible for every urban pest problem. Consider the following:

- The owner of a suburban, single unit, well-maintained residence contracts for pest management services to get rid of a recently introduced German cockroach infestation. It is not likely that the owner will accept a threshold of "a few" cockroaches remaining in the home following completion of the program. In this situation a pest threshold of zero is completely realistic.
- But suppose the manager of a 100-unit high-rise complex in a city, under contract with a pest management professional demands a pest threshold of no more than 5 cockroach sighting in the entire building in the course of a year. Could satisfaction be provided under such a threshold? Perhaps, but only if the manager was willing to pay a very substantial fee for such a demanding comprehensive service - and only with the total cooperation of all the tenants.
- As another example, could a pest management professional guarantee to eliminate every yellowjacket from school grounds? Of course not.

The factors that determine pest thresholds in urban IPM programs vary. Most people set their own pest thresholds according to the pest's relationship to their health, comfort, shelter, or personal feelings toward a particular pest (snakes, rabbits, deer, slugs, or cockroaches, etc.).

Step 3. Application of Pest Management Procedures

Following the inspection and the consideration of pest thresholds, the third step in IPM is implementing actual pest elimination procedures; that is, eliminating pests from buildings or managing them to acceptable and/or realistic thresholds. Nonchemical, chemical, or a combination of nonchemical and chemical control procedures may be implemented.

Nonchemical pest management programs are made up of three components: pest exclusion, pest habitat manipulation and pest removal. Chemical pest management programs, in most cases, involve the use of pesticides. Today's technology offers a wide range of biological, biorational, synthetic and natural toxicants. Nonchemical pest management practices are discussed below. Chemical pest management is discussed in Chapter 3.

The general public is increasingly aware of and prefers IPM alternatives to chemical pest control methods; often, nonchemical pest control practices play an important role in today's urban IPM programs, and the use of pesticides to solve pest problems is on the decline.

Nonchemical approaches should be considered first in all IPM programs because:

- they reduce the quantity of pesticides applied to the urban environment, and
- they often provide the best chance for long-term solutions to urban pest problems.

But be that as it may, it can be very frustrating to pest management professionals who realize that successful nonchemical programs (e.g. cleaning, keeping doors closed, keeping buildings in good repair, etc.) are dependent upon client participation - and clients may or may not be inclined to cooperate.

Pest Exclusion

It is obvious that the best method of managing urban pests is to deny them entry into our buildings in the first place. Usually, this is easier said than done because walls, floors, and roofs shift over time due to stress and ground movement. Small gaps and crevices are constantly being created, allowing pests entry into the structure. Nevertheless, in some cases exclusion is the only approach available for solving an urban pest problem (e.g. nuisance bats).

Client Name _____ Date _____

Address _____ Phone _____

Date of Previous Inspection _____ Inspector _____

Signature of Client Upon Inspection Completion _____

Signature of Inspector Upon Inspection Completion _____

EXTERIOR AREAS	Yes	No	NA
1. Landscaping well-maintained? (Shrubs, trees not overgrown, plants not in contact with the structure)?			
2. Is any wood stored directly next to the foundation?			
3. Foundation area free of clutter or trash?			
4. Rain gutters clear and free of debris?			
5. All ventilation vents in good repair?			
6. Window wells clean?			
7. Bird feeders well maintained?			
8. Exterior dog pens with food?			
9. Chimney capped to deny wildlife?			
10. Mulch touching the foundation of the home?			
11. All doors and windows pest-proof?			
12. Any wood in contact with the ground?			
13. Crawl space access tight to deny pest entry?			
14. Foundation walls/slabs in good repair?			
15. Trash areas clean and well maintained to deny pest access or breeding?			
16. All pipe and utility line penetrations well sealed?			
17. List of exterior pests located during the inspection or as reported by client?			
INTERIOR AREAS			
1. Basement well maintained and uncluttered?			
2. Presence of any pest evidence on sill plate in basement?			
3. All water pipes in kitchen, bath, and utility areas in good repair and not leaking?			
4. Attached garage well organized with access to perimeter walls?			
5. All foods stored within garage in pest-proof cans or containers?			
6. Crawl space dry and well ventilated?			
7. Any junk or discarded wood in crawl space?			
8. Kitchens, pantries, baths, closets, etc., generally cleaned of spilled food (underneath and behind appliances and furniture)?			
9. Attic well organized, with access to all perimeter walls or corners?			
10. Any rooms, closets, or other areas which are too cluttered to allow for pest inspection?			
11. Interior pests and their locations noted during this inspection (or as reported by client)?			
12. Monitors installed in attics, food closets, storage areas, crawl spaces, basements and garages to detect pests?			
13. Any conditions noted for this residence which contribute to pest problems?			
Comments and Recommendations to Client			

Table 2-2. Example of a checklist inspection guide for residential accounts.

AREA	Yes	No	NA	Comments
EXTERIOR				
1. Pest harborages under objects lying or stored directly on the ground?				
2. Any food spillage around shipping/receiving docks?				
3. Garbage handling systems well-maintained, including storage areas, containers, cleaning methods, and trash handling?				
4. Drainage systems functioning properly?				
5. Weed control programs in place?				
6. Perimeter insect control programs in place?				
7. Perimeter rodent control programs in place?				
8. Any pest pressure from surrounding areas or buildings?				
9. Is the facility pest-proof?				
10. Are doors, windows, and utilities in good repair and all thresholds pest-proof?				
11. Does the facility practice good pest denial by keeping doors and windows closed?				
INTERIOR				
1. Walls, ceilings and floors in good repair and kept clean?				
2. Suspended ceilings kept clean and accessible and ceiling monitors in place?				
3. Elevator shafts well-maintained?				
4. Floor drains clean?				
5. All utility lines properly sealed?				
6. Premises relatively free of clutter: cardboard, boxes, old equipment, etc.?				
7. All food preparation surfaces cleaned?				
8. Light fixtures properly cleaned?				
9. All employee areas (rest rooms, cafeterias, locker rooms) clean and orderly?				
WAREHOUSING AND STORAGE				
1. Inspection aisles maintained 16 - 18 inches away from walls?				
2. Warehouse floor well sealed to deny entry of ants and other pests?				
3. Quick removal of spilled products?				
4. Isolated areas for damaged products?				
5. Products properly rotated?				
Comments and Recommendations to Client:				

Table 2-3. Abbreviated inspection checklist report form for commercial food handling accounts.

Often it is people who are most responsible for allowing entry of flies, rodents, bees, urban wildlife and other pests into buildings. Doors and windows are continually left open, vents remained unscreened, chimneys uncapped and door thresholds unrepaired.

Pest exclusion programs have two components:

- pest-proofing of buildings.
- pest denial practices.

Pest-Proofing. Pests can be excluded from buildings by repairing structural gaps, installing proper door thresholds, or utilizing screens, chimney caps, door closure devices, etc. Entire books have been written on this subject. The following list provides a few common examples of important, basic pest-proofing practices that pest management professionals should keep in mind while conducting routine building inspections.

Providing clients a checklist of necessary structural repairs helps them help themselves in keeping pests out of buildings and results in a reduced need for pesticide applications.

- All buildings gaps should be reduced to ¼ inch to deny mouse entry and ½ inch to deny rats.
- Fascia boards provide one of the most common entry points for pests. (A fascia board is a flat board often used horizontally to finish off the edge of the roof.) They must always be kept flush and well sealed to exclude ants, bats, rodents, bees, wasps, cluster flies, ladybird beetles and many other pests from gaining entry into attics.
- Anti-pest tension strips or heavy-duty door brushes are recommended for door thresholds of commercial accounts.
- Install door sweeps or thresholds at the base of all exterior entry doors. While lying on the floor, check for light filtering under doors. Gaps of 1/16 inch or less will permit entry of insects and spiders; ¼ inch-wide gaps (the diameter of a pencil) are large enough for entry of mice; ½ inch gaps are adequate for rats. Pay particular attention to the bottom corners as this is often where rodents and insects enter.
- Apply caulk along bottom outside edge and sides of door thresholds to exclude ants and other small insects.
- Garage doors should be fitted with a bottom seal constructed of rubber (vinyl seals poorly in cold weather).
- Gaps under sliding glass doors can be sealed by lining the bottom track with ½- to ¾-inch-wide foam weatherstripping.
- Foundation ventilation openings should be screened with ¼ inch mesh.
- Windows should be screened with 12 inch mesh to exclude large flies; 18 inch mesh is necessary to exclude small flies such as mosquitoes and gnats. Repair gaps and tears in window and door screens.
- Seal utility openings where pipes and wires enter the foundation and siding, e.g., around outdoor faucets, receptacles, gas meters, clothes dryer vents, and telephone/cable TV wires. Holes can be plugged with caulk, cement, urethane expandable foam, steel wool, copper mesh (Stuffit®), or other suitable sealant.
- All cracks in slab floors (especially the large slab floors of warehouses, schools, hospitals and other similar commercial buildings) should be sealed to deny entry of ants, termites and other pests.
- Caulk cracks around windows, doors, fascia boards, etc. Use a good quality silicone or acrylic latex caulk. Although somewhat less flexible than pure silicone, latex- type caulks clean up easily with water and are paintable. Caulks that dry clear are often easier to use than pigmented caulks since they don't show mistakes. Use a good caulking gun. Features to look for include a back-off trigger to halt the flow of caulk when desired, a built-in "slicer" for cutting the tip off of new caulking tubes, and a nail for puncturing the seal within. Prior to sealing, cracks should be cleaned and any peeling caulk removed to aid adhesion. For a professional look, smooth the bead of caulk after application with a damp rag or a moistened finger.
- All roof, attic and crawl space vents and exhaust stacks should be screened to deny birds, wildlife and insect pests.
- Residential chimneys should be capped with heavy screen wire to deny entry of raccoons, squirrels and birds.

Many pest management professionals use caulks and temporary copper meshes around utility and plumbing lines routinely to seal openings into homes and commercial building. This effort provides a valuable service in reducing entry access into a structure (especially for mice).

Pest Denial. Pest denial is the practice of denying pests entry into buildings through common sense practices such as keeping doors and unscreened windows closed. Although this may seem obvious, doors and windows remain major points of entry for flies and rodents in commercial and food handling accounts. Even in sensitive accounts such as schools, it is common to find hall doors open wide in early fall which is when yellowjackets are most active!

In commercial accounts, screen doors should always be equipped with self-closing devices. In industrial plants and warehouses, the new flexible fast-closing zip doors enable shipping/receiving operations to proceed without leaving large doors open for prolonged periods. Large perforated-metal bay doors exclude pests but allow air flow for employees comfort.

Pest Habitat Manipulation

Pest habitat manipulation is the second nonchemical component of urban IPM. Habitat is the native environment of a pest, that is, the location where it lives naturally and has access to food, water and harborage (shelter). Simply put, a pest's habitat is where it resides and is likely to be found. Many pest animals continually strive to inhabit our buildings because they provide warmth, protection, food and water - an artificial habitat.

Because all living organisms require the basic elements of nourishment and shelter to survive, habitat manipulation is the most basic form of pest management. It is also the approach that often provides the best long-term pest management because it prevents pests from thriving. In other words, by

manipulating a pest's habitat to deny access to vital resources, we can effectively control or eliminate the pest problem.

For the purpose of discussion, there are three ways we can manipulate habitat to reduce or eliminate pest populations:

- Implement good sanitation (e.g. remove firewood stacked against the building to reduce the amount of harborage available to carpenter ants, rodents and other pests).
- Modify the pest's atmosphere (e.g. reduce the humidity in a basement to render it less suitable for the survival of cockroaches and other insect pests).
- Install repellent devices (e.g. placement of prickly wires on building ledges to reduce the number of perching areas).

Pest Removal

Regardless of our best efforts to employ sanitation and pest exclusion techniques, some pests may persist. Occasionally, they may even become established in which case additional control measures may be warranted.

Pest removal is perhaps the most basic, direct, nonchemical method of reducing or eliminating a pest population.

Each of these approaches is widely used in urban pest management:

- Lethal trapping.
- Live trapping and removal.
- Direct removal techniques.

Lethal Trapping Programs. Lethal trapping is probably the most widely used, nonchemical pest management procedure. Some common examples include:

- Snap traps for rat and mouse control.
- Glue board traps for rodent control and insect monitoring.
- Curiosity traps for mouse control.
- Insect light traps for flies, moths, and other flying insects.
- Fruit fly jar traps.
- Harpoon mole traps.

Most people are familiar with rodent snap traps and glue boards. The common mousetrap typically kills a mouse which is drawn to a trap bait or inadvertently steps on the trigger. Glue traps kill by retaining the pest in the glue until it succumbs to injury, stress and exhaustion.

Traps have some advantages over the use of chemicals:

- They can be used in sensitive environments where pesticide use may be undesirable (e.g. schools, hospitals).
- Results are readily observable.
- The possibility of dead animal odor (which might occur when a rat dies in a wall void after ingesting poison bait) is eliminated.

Traps also have several drawbacks:

- They generally are not as effective as pesticides in controlling large populations.
- Some rodents and birds naturally avoid traps.
- They can be labor intensive.
- In some cases, the use of lethal traps results in inhumane death.

The use of each type of lethal trap requires a specific skill. Rodent trapping programs require sufficient numbers of traps, strategically placed, for optimal results. Since rodents are not drawn from long distances to attractive baits, trap placement must be precise and the location of trap location hinges on a good inspection to identify high pest activity areas.

Consider this simple program: the trapping of 2 or 3 mice in a residential kitchen. This requires 8-12 traps, strategically placed behind the kitchen range and refrigerator, on food shelves, inside base cabinets, under the sink, around the inside perimeter of the attached garage and in any other place where the mice are active. But regardless of the pest situation, when traps are used it is essential to use enough traps to produce quick results.

When considering insect traps, it is important to note that most (e.g. roach traps, yellowjacket traps, fruit fly traps) do not provide control of the specific pest population. Insect traps are most effective in helping to monitor the magnitude of an infestation (e.g. in determining that roaches are most conspicuous in the northwest corner of the kitchen or that fruit flies are most active in room 3, etc). But some traps such as yellowjacket and fruit fly traps can provide welcome temporary relief until more intensive efforts are implemented.

Commercial insect light trap are widely used by the food and pharmaceutical industries. These traps (also called bug zappers) play a very important role in eliminating the occasional flying insect that enters through an open door during normal operations. These traps are very effective and help reduce the contamination threat of flies and other flying insects to our food and drugs.

Still, these traps cannot provide long-term control of a fly problem. When flies are persistent inside and around a restaurant they are best controlled by identifying and cleaning breeding sites (dumpsters, dirty accumulations beneath sink, etc.) and by using good pest exclusion techniques.

Perhaps it also should be mentioned here that backyard bug zappers do little or nothing to control insect pests around the home; most mosquitoes, for example, are not attracted to these units.

Live-Trapping Programs. Live-traps are commonly used in urban pest management programs to remove offending urban wildlife, certain mammals and birds. Woodchucks, raccoons, skunks and tree squirrels are usually live-trapped and removed from the premises. It is important to note there are no pesticides (other than repellents) registered for use on wildlife in Tennessee.

Live-traps also are used to remove certain birds such as geese and pigeons from commercial sites. Programs involving the live-trapping of mammals and/or birds requires skill and training as well as compliance with various federal and state regulations. In most cases, wildlife and bird live-trapping programs are conducted by professionals who are permitted and skilled in these areas.

Direct Removal. The most obvious example of a direct pest removal program might be the use of a pellet rifle to shoot a bird that is disoriented inside a large structure. Another example would be the use of an insect net or coffee can to collect a single bat lost inside a building.

One direct removal practice which has recently taken on a significant active role in urban pest management is the use of vacuums for removing pests. Specialized vacuums are used

commonly to remove German cockroaches from cabinets and the cracks and crevices where they hide. Although vacuuming cannot eliminate an entire cockroach infestation, it immediately reduces the population, therefore it is an excellent nonchemical technique for use prior to baiting programs aimed at wiping out severe German cockroach infestations.

Vacuums are also very effective in removing cluster flies, wasps, spiders, ladybird beetles and various other occasional invaders from residential accounts. Daily vacuuming also provides significant reduction of flea populations in carpeting provided the vacuum cleaner has a beater bar brush.

Step 4. Evaluation: Monitoring of Pest Populations and the Management Program, and Repeating Procedures as Needed.

Most IPM programs are an ongoing processes. It is important to note that Step 4 does not state reapplying pesticides as needed, but repeating procedures as needed. IPM programs require constant reevaluation, based on monitoring. Monitoring may involve the use of traps and/or detailed inspection, using a flashlight. It is only through dedicated monitoring and assessment of each particular situation that various management procedures - chemical and nonchemical- can be integrated into an effective pest management program.

Review Questions

1. Which is NOT a step in an IPM program?
   - A. Inspection.
   - B. Scheduled pesticide applications.
   - C. Determination of pest thresholds.
   - D. Monitoring of pest populations and management program.

2. Which is NOT an objective of a general inspection?
   - A. Confirm pest identity and presence.
   - B. Identify the location and source of the pest problem.
   - C. Determine the extent of the pest infestation.
   - D. Locate pesticide drift.

3. A good inspection technique is to first identify areas within a structure that offer a tropical environment (warmth, moist, dark and humid).
   - A. True
   - B. False

4. Which is NOT likely to be used as a pest travel route?
   - A. Conduit
   - B. Electrical wires
   - C. Pipes
   - D. Color pattern in a rug

5. Which is NOT an example of pest-proofing?
   - A. Building gaps reduced to ¼ inch opening.
   - B. Vents screened with ¼ inch mesh.
   - C. Using a vacuum to remove pests.
   - D. Sealing areas where utility lines enter a structure.

6. Habitat is a location
   - A. where a pest lives naturally and has access to food, water and harborage.
   - B. with many cracks and crevices.
   - C. with many branches to increase diversity.
   - D. is a door, window or other opening into a structure.

7. Which is NOT an example of pest habitat manipulation?
   - A. Installation of prickly wires on a building ledge.
   - B. Good sanitation.
   - C. Use of harpoon mole traps.
   - D. Reduce the humidity in a basement.

8. Which is NOT an example of a lethal trapping program?
   - A. Rodent snap traps
   - B. Insect light traps
   - C. Harpoon mole traps
   - D. Multiple-catch traps

9. IPM stands for
   - A. Insect Pest Management
   - B. Integrated Pest Management
   - C. Integrated Pesticide Management
   - D. Insect and Pesticide Management

10. The four main components of IPM listed in this manual are:
   - A. Inspection, Pest threshold determination, Management procedures and Evaluation.
   - B. Inspection, Perimeter treatments, Management procedures and Evaluation.
   - C. Inspection, Identification, Management procedures and Evaluation.
   - D. Inspection identification, Perimeter treatments, Management procedures and Evaluation.

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

Chapter 3 Pesticides and Application Equipment for Urban IPM Programs

Pesticides are available in various formulations to expedite safe and effective application (Table 3-1). The following brief discussion represents those insecticide and rodenticide formulations used most often in urban pest management. Pest management professionals must understand the importance of choosing the right formulation for a specific job. Economy, safety and environmental protection must be taken into consideration when choosing a pesticide.

Pesticide Formulations Used in Urban Pest Management

Insecticide Formulations

Liquids. The liquid residual insecticide formulations most commonly used in urban pest management are the wettable powders (WP), soluble powders (SP), emulsifiable concentrates (EC) and flowable microencapsulates (FM).

Each of these formulations when tank mixed with water provides advantages for a specific use. Wettable powders are easy to store and mix. Wettable powders are very low in odor and tend to persist longer on porous surfaces such as concrete, wood and paint than do emulsifiable concentrates. However, wettable powder formulations must be agitated in the tank more frequently than emulsifiable concentrates.

The flowable microencapsulated formulations provide outstanding longevity in moist or wet conditions such as a rain following an exterior perimeter application. Other formulations break down under wet conditions. Microencapsulated pesticides tend to be more expensive than other formulations.

Baits. Baits (Figure 3-1) have become one of the most effective formulations for use against cockroaches and ants and they have always been the primary formulation for use against rodents. In addition to their effectiveness, baits offer ease of application, no perceptible residual odor and excellent longevity. It is important to note that in order to be effective, baits must be consumed by the target pests and they are less attractive to pests where unsanitary conditions provide alternative food sources.

Courtesy, UT EcoPP

Figure 3-1. Some baits used for insect control.

Baits are also considered one of the key components of the IPM movement due to their low odor and application in areas inaccessible to people, pets and wildlife.

Dusts. Insecticidal dusts provide the greatest longevity of all formulations providing they are applied to dry areas such as wall voids. If not carefully applied, dusts can inadvertently drift or be carried into nontarget areas.

Granulars. Granular insecticides are formulated for exterior applications where it is desirable to provide good longevity in wet, hot or other specific environmental conditions. Granular insecticides are typically used as a perimeter treatment around homes to control occasional invaders such as millipedes and ants.

Rodenticide Formulations

Most rodenticides are cereal-based food baits or liquid baits. There are two broad groups of active ingredients used in rodenticides: anticoagulants and nonanticoagulants.

About 90 percent of all rodenticide products used in urban pest management are anticoagulants. As their name implies, the anticoagulants kill rodents by preventing their blood from coagulating (clotting) thus causing the animal to bleed internally and eventually die.

The anticoagulant rodenticides are classified as first- or second-generation anticoagulants. First-generation anticoagulants (diphacinone [Eatons], chlorphacinone [RoZol]) are multiple-dose rodenticides. Rodents must consume treated bait for several days to ingest enough rodenticide to cause death.

The second-generation anticoagulants (brodifacoum [Talon, Finale], bromadiolone [Contrac, Maki], difethialone [Generation]) were developed when rat and mouse populations became resistant to the first-generation anticoagulants. Second-generation anticoagulants can cause rodents to die after fewer feedings than the first-generation products.

The nonanticoagulant rodenticides include compounds which use the active ingredients bromethalin (Vengeance™), cholcalciferol (Quintox™) and zinc phosphide (many different

Insecticides
- Bait toxicants
  - hydramethylnon
  - sulfluramid
  - abamectin
  - imidacloprid
  - fipronil
  - indoxacarb
  - acetamiprid
- Botanicals
- Inorganics
  - Boric acids
  - Silica
- Insect growth regulators
  - methoprene
  - pyriproxyfen
  - hydroprene
  - hexaflumuron
  - noviflumuron
- Nonrepellent (to termites) insecticides
  - imidacloprid
  - fipronil
  - chlorfenapyr
- Pyrethrins
- Pyrethroids
  - Many (e.g. bifenthrin, cyfluthrin, cypermethrin, deltamethrin, fenvalerate, lambda-cyhalothrin, permethrin, resmethrin, etc.)

Fumigants
- sulfuryl fluoride (Vikane)

Repellents
- bird repellents (hot foot gels, sprays, etc.)

Rodenticides
- anticoagulant poison baits (bromadiolone, brodifacoum, etc.)
- non-anticoagulants (zinc phosphide, bromethalin)

Herbicides
- many

Avicides
- avitrol

Table 3-1. Some examples of pesticides and pest control substances most commonly used by urban pest management professionals.

name brands). Each of these active ingredients kills via different modes of action. Therefore, as with all pesticides, especially nonanticoagulants, labels should be carefully reviewed prior to using the product.

Rodenticide Baits. Rodenticide baits are typically formulated into

- compressed grain pellets,
- extruded blocks (similar to dry dog food),
- ground cereal meal, or
- liquid baits.

The pellets and cereal meals are available in large, bulk quantities or in small packets. Like the insecticides, each rodenticide formulation has distinct advantages for certain applications.

Compresses Grain Pellets. Grain pellets are cost effective and easy to apply. The professional can easily determine the amount to apply for light, moderate or heavy infestations. Care must always be taken as rodents may carry pellets away from the application site and store them in undesirable locations.

Extruded Blocks. Block baits are one of the leading rodenticide formulations because they hold up well in both interior and exterior baiting programs. Blocks can be secured within bait stations to prevent rodents from moving the bait to another location that might endanger people, companion animals or wildlife. Using block baits maximizes baiting safety.

Ground Cereal Meal. The ground meal baits are less susceptible than grain pellets to be carried off by the rodent, but they may absorb moisture from the air and become moldy.

Both pellets and cereal meal baits are available in packets. It is more important to note that safety must be a top priority during packet bait application. Rodents may carry packets or drop them en route to locations easily accessible to humans and nontarget animals. When packets are stuffed down rat burrows it is common for rats to eject the packets back on top of the ground.

Liquid Baits. Liquid formations are attractive to rodents in environments where water is scarce or absent; bakeries, dry-goods warehouses, etc. Anticoagulants formulated as concentrated liquids can be diluted with water, on the job, to make liquid baits. But because liquids can be spilled easily, extra caution is necessary during application to guard against endangering livestock, pets or wildlife.

Tracking Powders. Rodenticide tracking powders is also a common rodenticide formulation, but it is not a food bait. Tracking powders are applied in rodent burrows or protective boxes or on rodent runways. Rodents pick up the toxic powder on their feet and bodies as they walk through it and then ingest it through daily grooming activities. The active ingredient used in tracking powders may be one of the anticoagulants (diphacinone or chlorphacinone) or nonanticoagulants (zinc phosphide).

To be effective, tracking powders must contain relatively high concentrations of active ingredient (up to 10 percent is

Courtesy, UT E&PP

Figure 3-2. Hand-held compressed air sprayer.

used with zinc phosphide tracking powders for mice. *Thus, they are potentially more hazardous than other rodenticide formulations and must be applied with extra caution.*

Pesticide Application Equipment

In addition to choosing the best formulation for the job, pesticide application equipment selection and its proper use is also critically important to achieve safe, economical and successful control of urban pests.

Sprayers

Liquid pesticides are applied with compressed air sprayers (Figure 3-2) which are available in various sizes and models including backpack sprayers for large jobs. By using special nozzle tips and adjusting them as required, a liquid pesticide can be applied in a fan pattern for spot and general treatments or in a pin stream for application into cracks and crevices. The latter is preferred for targeting cockroaches, ants and several urban pests.

Sprayers always must be pressurized according to label directions for the specific target pest and pesticide product. Most labels recommend pressures of 20 psi or less for crack and crevices. Excessively high pressures can cause pesticide drift or run off the application surface increasing the potential for contamination problems. Sprayers must also be kept in good working condition to avoid malfunctions such as leaking hoses, gaskets and nozzles.

Emphasis should be placed on the correct mixing of liquid pesticide formations in the sprayer to avoid applying pesticides at incorrect concentrations. Product labels and sprayers use directions always must be followed closely to ensure efficacy (produce the desired effect) and pesticide safety.

For many years, the sprayer was the most common piece of equipment identified with a pest management professional. Today it remains an important tool and overall may still be the most widely used piece of pest control equipment.

Fogging Machines and Aerosols

Various types of equipment, broadly referred to as fogging machines and aerosol generators are available for applying liquid insecticides in very small particles as aerosols into rooms and enclosed areas. Fogging operations are widely known as space treatments.

The various models of cold fogging equipment are known as Ultra Low Volume (ULV) applicators. They are commonly used for fogging operations inside food warehouses, commercial offices, etc. to provide quick knockdown and temporary control of flies and stored product moths and beetles. Thermal fogging machines are occasionally used outdoors to control flies and mosquitoes.

It is important to note that in most cases fogging equipment kills only the insects present in the air during the time of the treatment. Aerosol insecticides unless forced under pressure (see paragraph below) do not penetrate into boxes or equipment to kill hidden pest populations.

Pests in difficult-to-reach areas such as wall voids, ceilings, floors, cabinets and certain types of utility voids can be accessed with specialized aerosol generators such as Actisol® and Micro-Injector®. These machines are similar in concept to cold foggers, but they employ specialized application wands, nozzles and power to force the insecticide deep into the target voids.

Fogging and aerosol equipment must always be used with extreme care and all label direction for the equipment and pesticide must be closely followed. Fires, explosions, serious pesticide contamination and poisoning have resulted from the improper use of fogging equipment.

Bait applicators

Bait applicators (also referred to as bait guns) are used to apply the various gel and paste baits used for cockroach control. A typical bait gun is shown in Figure 3-3 although there are several different models used in the industry and manufacturers are likely to produce even more in the near future.

Specialized dispensing tips on the bait guns allow the professional to administer the bait into the various cracks where it is most likely to be encountered by pests. The bait gun is an integral piece of equipment for cockroach control.

Figure 3-3. Bait applicators allow bait placement into cracks and crevices.

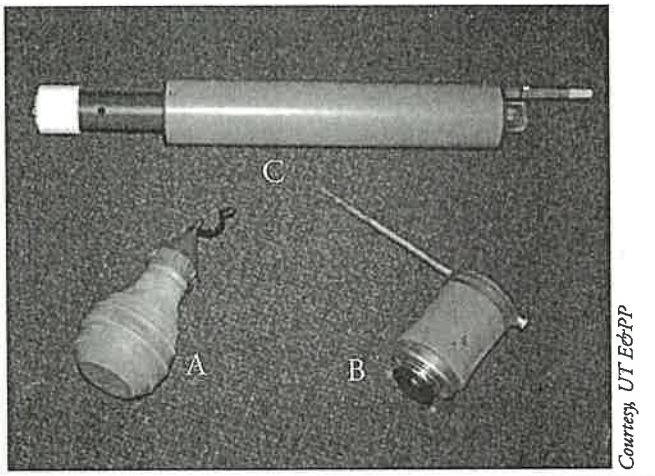


Figure 3-4. Three types of hand held dusters used by pest management professionals: bulb (A), bellows (B) and plunger (C).

Ready-to-Use Pesticides

Many pesticides are available to the professional in ready-to-use formulations and equipment: pressurized aerosols, liquids, foams, dusts and rodenticide bait stations. Ready-to-use pesticides and equipment must be stored, used and disposed of in strict accordance with the product's label directions. Otherwise, pesticide contamination can occur very easily.

Dust applicators

Dusts can be applied into cracks and voids with hand-held dusters (Figure 3-4) when the situation calls for small amounts of insecticide to be carefully applied. Large, plunger-type dusters or power dusters are used to dust larger areas.

Dusting equipment must be stored carefully. Care must be taken to prevent dusts from spilling or leaking out of dusters and contaminating the storage compartments.

Dusting equipment should never be cross-contaminated. Once a duster has been used for a given insecticide, it should never be used to apply another. Dusts, granular and rodenticide tracking powders must NOT be dispersed through dusters used previously to apply other products. Separate application equipment for each is essential. And every piece of dusting equipment must be clearly labeled as to its contents.

Bait Stations

To minimize baiting hazards to people, pets and nontarget animals, most rodenticide baits are enclosed in various types of bait boxes (often called bait stations). By law, tamper-resistant

Courtesy, UT Ed-PP

Figure 3-5. Poisoned baits are usually placed in bait stations to prevent children or nontarget animals from being exposed to the toxic material.

bait boxes (Figure 3-5) must be used in situations where baits may be accessible to children or nontarget animals. Tamper-resistant boxes are usually constructed of metal or heavy pliable plastic. Some boxes provide only minimal resistance to tampering while others are elaborately constructed, extremely durable and equipped with various locking mechanisms. It is important to note that bait containers are not considered tamper-resistant until they're secured in place to the ground, floor, walls or heavy object. It is wise to select bait stations with self-contained bait or to secure the bait within the stations. Securing the bait within a station helps protect rodents from carrying it to areas accessible to people, pets and nontarget wildlife.

Safety

Protecting the Applicator

Most ready-to-use formulations and properly diluted pesticides commonly used in structural pest management are not highly toxic. Still, most of the pesticides used by professionals are packaged as concentrates which must be diluted and mixed according to label rates for proper application. If safety and care are not taken seriously, the mixing, handling and application of even low-toxicity pesticides can result in serious contamination or poisoning.

Pest management professionals work with pesticides on a daily basis and the potential for gradual accumulation of pesticides in their systems is a real possibility if proper safety gear and clothing are not worn. Many pesticides labels state specifically which safety equipment and clothes are required. A minimum requirement of gloves (disposable nitrile) and goggles is now the standard safety gear to be worn during mixing and handling.

In cases where pesticide particles (fogs, dusts, mists and vapors) may be encountered or inhaled, approved respirators must be worn. Every pest management professional must be trained how to fit, use and store respirators. Training on cartridge replacement procedures is important as well.

Protecting Clients and Companion Animals

Because professionals often work in buildings where people and companion animals live, pesticide application safety is most important. For example, care should be taken not to spill liquid insecticide or allow them to drift into areas where they can be encountered by people and pets.

In order to minimize the possibility of exposure,

- pesticides should never be mixed inside the client's building;
- liquid pesticides never should be applied at pressures higher than those on the recommended product label; and
- wet residuals should never be available for contact in occupied accounts.

Fish and reptile pets must always be considered because very small amounts of certain diluted pyrethroid pesticides can cause rapid death.

Whenever rodent baits and tracking powders are applied in and around buildings, forethought is required to ensure that people and nontarget animals cannot encounter the rodenticide at later times. Consideration also must be given to the fact that rodents can move baits away from baiting sites and hoard them in nontarget areas. Each year, poison control centers receive many calls regarding human poisoning from rodenticides. And many cats and dogs encounter and/or ingest rodenticides annually, often resulting in the loss of beloved companion animals.

Rodenticide tracking powders are safest when installed in bait boxes, enabling the professional to retrieve all remaining powder upon completion of the pest management program. Tracking powders should never be used in a manner in which residents, maintenance personnel or nontarget animals can inadvertently come in contact with them.

Safety is also a concern when professionals install non-chemical control devices such as snap traps, live traps and glue boards:

- Fingers and other bones can be broken with rat traps.
- People, pets and wildlife can be hurt if they become entangled in glue boards.
- Dogs and cats may be hurt when they enter live traps and are not released soon after capture.

Protecting the Environment

If not mixed or applied correctly, many pesticides used in urban pest management can damage water systems, valuable plants, including turf and trees, and buildings.

Many of the pyrethroid insecticides are rated extremely toxic to fish and other aquatic organisms. Disposal of pesticide packages and containers is of paramount importance. So care should be taken not to contaminate ground or surface water or any type of water system. The same is true when cleaning sprayers and other pesticide application equipment.

Secondary hazards are associated with rodenticides and must be kept in mind when implementing baiting programs. In most cases, a dog or cat that has eaten a few mice or rats killed by conventional rodenticides is not at a significant risk. However, in large scale rodent baiting operations there is a very definite baiting hazard when pets and nontarget animals have continuous access to poisoned rodents. Owls and other predacious birds have been poisoned by feeding on rats and mice that had ingested anticoagulant poisons used as baits around severely infested structures. Rodent baits are not only toxic to most mammals that might eat the bait, they are also toxic to fish.

What is the bottom line when it comes to applying pesticides in urban environments? Read the label!!! Every pesticide label clearly states the specific environmental, physical and chemical hazards associated with the product.

Before using any pesticide:
READ THE LABEL.

A more detailed description of pesticides and their use is provided in the core manual, *Applying Pesticides Correctly: A Guide for Private and Commercial Applicators.*

Review Questions

1. Which cannot be made into a liquid formulation?
   A. Extruded block
   B. Wettable powder
   C. Emulsifiable concentrate
   D. Soluble powder

2. Which is one of the most effective formulations for use against cockroaches, ants and rodents?
   A. Dust
   B. Liquids
   C. Baits
   D. Granulars

3. Anticoagulant rodenticides kill rodents by
   A. preventing blood from clotting.
   B. preventing formation of vitamin K.
   C. losing calcium in the blood.
   D. preventing the formation of energy.

4. Rodents may store grain pellet pesticides in undesirable locations.
   A. True
   B. False

5. First-generation rodenticides must be fed upon more than once for rodents to receive a lethal dose.
   A. True
   B. False

6. Which are potentially more hazardous than other rodenticide formulations and must be applied with extra caution?
   A. Ground meal baits
   B. Grain pellets
   C. Extruded block
   D. Tracking powder

7. Which formulation provides outstanding longevity in moist or wet conditions?
   A. Emulsifiable concentrate
   B. Soluble powder
   C. Dust
   D. Flowable microencapsulate

8. In most cases, _____ kills only the insects present in the air during time of treatment.
   A. Baiting
   B. Fogging
   C. Spraying of residual insecticides
   D. Dusting

9. Once a duster has been used for a given pesticide, it should never be used to apply another.
   A. True
   B. False

10. Rodent baits are not only toxic to most mammals that might eat the bait, they are also toxic to fish.
   A. True
   B. False

Answers: 1. A, 2. C, 3. A, 4. A, 5. A, 6. D, 7. D, 8. B, 9. A, 10. 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 of some of the more common species. For more complete information on identifying cockroaches, ants, or flies, refer to some of the 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 management technicians indicated ants were the main reason for callbacks. Management efforts often worsen the problem.

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.

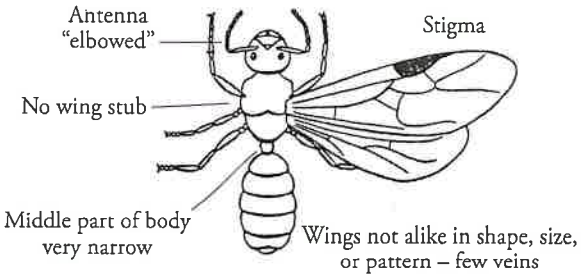
Nests often can be located by following "trails" of foraging ants. Indoors, ants nest almost anywhere. Quickly killing foraging ants rarely solves an ant problem in the home because the colony remains unaffected.

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

Ants form new colonies by having a mating flight or from budding. Most colonies are started by these newly mated winged female 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 by budding which occurs when workers, brood and often one or more queen ants, 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, in a process called trophallaxis. Baiting to control ants takes advantage of these



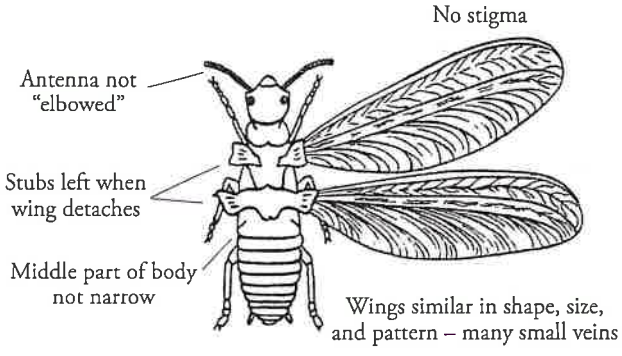


Figure 4-1. Comparison of a winged ant and winged termite.

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 health care facilities.

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. Often more than one nest is present or the nest cannot be found. In this case, baiting is important. Although pest-proofing provides a more permanent barrier, outdoor repellent pesticidal barriers may be used as a supplement when nests are only found outdoors. New nonrepellent insecticides are now available for ant control. The advent of nonrepellent insecticides may challenge much of our current ant management guidelines. For more detailed information on ant identification and management, see *PB1629 Managing Structure-Invading Ants* available from your local county Extension office or Field Guide for the Management of Structure-Infesting Ants by Stoy Hedges.

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. Improper identification is at least partially responsible for the ant management problems were are experiencing today. See Table 4-1 for common structure-invading ants found in Tennessee.

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.

Sanitation. Ant problems occur in homes and structures primarily because food, water and favorable nesting sites are available there. Eliminate food and moisture sources that could compete with ant baits. Use a mild detergent to wipe ant trails and remove the trail pheromone, but 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 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 a structure, because ants can use them to gain access to the home. Pull mulch, a common nest site, 12 -18 inches away from the foundation of the structure. More information on sanitation and exclusion practices are found in Chapter 2 of this manual.

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 index 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.
- 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.
- Squeeze a few frozen ants before adding them to the alcohol and add the odor description to the specimen identification form.

Monitoring, Inspection and Nest Location. Because many nests can occur in a 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 re-infest in the future. Use a smear of honey on an index card and place around the structure in window sills, and near water and food sources indoors and outdoors. Once all areas of foraging activity are located, they can be baited. If the nest can be located, it can be treated directly.

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. 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.

Some ants are fickle, especially Pharaoh ants, and are reported to switch feeding preferences. Prior to placing baits,

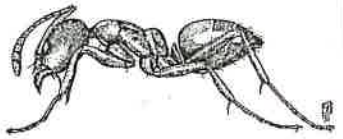
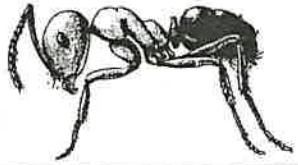
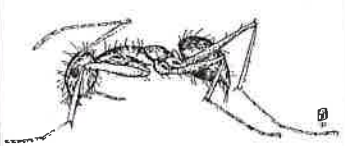
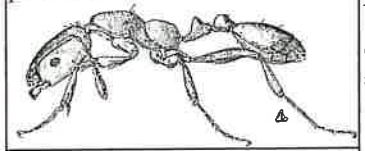
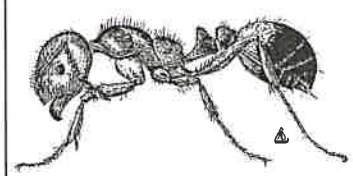
Pest	Pest identification	Behavior/Damage	Management
Odorous house ant, *Tapinoma sessile* 	**Nodes on waist:** one, very flat, barely noticeable node hidden by the gaster **Gaster tip:** no circular opening **Worker size:** 1/8 inch **Odor when crushed:** "disagreeable, rotten-coconut-like" or a banana-like odor **Color:** brown to black	**Foraging:** They avoid other species at a bait even they arrived first. **Outdoors:** feed on living & dead insects, and honeydew from aphids. **Indoors:** feed on sweets and other household foods and often trail to water. **Nest Sites:** shallow nests in shady, moist areas such as mulch, pine straw, stones, logs, etc and bee hives. Indoors, nests in wall voids near pipes and heaters, bath-traps, termite-damaged wood, beneath carpets and toilets. Moves indoors during periods of heavy rain. Move nests often. Many nests may occur around structures. **Life cycle:** This species establishes multiple queen colonies. Male odorous house ants collected from lights from the end of May through the end of June.	In general, this ant prefers sweet baits. **Program 1 for warm, dry weather:** Apply a nonrepellent insecticide to foundation base, active trails and potential entry points in conjunction with liquid baits placed in landscape just beyond spray zone. **Program 2:** Treat areas of activity indoors with dust, bait or spray and combine with non-repellent insecticide to foundation base. Replenish baits as needed.
Argentine ant, *Linepithema humile* 	**Nodes on waist:** one **Gaster tip:** no circular opening **Worker size:** 1/8 inch **Odor when crushed:** "disagreeable, rotten-coconut-like" or a banana-like odor with an additional faint musty odor **Color:** light to dark brown	**Foraging:** honeydew from aphids, nectar, fruit tree buds, ripened fruit; indoor, sweets, oils, eggs and meats **Nest Sites:** nest outdoors in mulch and soil, along pine tree roots and into the tree, rocks, etc. Many nests may occur around structures. **Life cycle:** Many queens in colonies and thus enormous number of individuals because nearby budded colonies are not aggressive toward one another. Colonies bud.	Argentine ants not widespread in Tenn, but localized pockets occur in Knoxville, Chattanooga and other areas. See odorous house ants for management guidelines.
Yellow or Citronella ant *Acanthomyops spp.* 	**Nodes on waist:** one **Gaster tip:** circular opening **Worker size:** relatively large, about 3/16 inch **Odor** when crushed: lemon or citronella **Color:** yellow to yellow-red	**Foraging:** honeydew from subterranean sucking insects; tend these insects; seldom seen foraging during daylight hours; may be found in termite stations **Nest Sites:** underground, under slabs **Life cycle:** Yellow ants may swarm in early spring, but when a colony is under a 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. Not a common pest.
Allegheny mound ant, *Formica sp.* 	**Nodes on waist:** one **Gaster tip:** circular opening **Worker size:** relatively large, 1/8 - 1/4 inch **Shape of thorax:** uneven (distinguishes it from carpenter ants) **Color:** head and thorax read, abdomen and legs dark	**Foraging:** feeds on living and dead insects, honeydew. Usually not found indoors, but may be seen around patios and porches. Excellent predator of insects. **Nest Sites:** large mounds (which causes some confusion with fire ants) often located at interface of woods and fields **Life cycle:** multiple queen colonies; one colony may have several connected mounds. Reproduce through mating flights in late spring/summer.	Granular ant baits (not baits with oils as attractant), or drench or other individual mound treatments.
Black field ant, *Formica sp.* 	**Nodes on waist:** one **Gaster tip:** circular opening **Worker size:** relatively large, 3/8 inch **Shape of thorax:** uneven (distinguishes it from carpenter ants) **Color:** black to very dark brown	**Foraging:** wide variety including living and dead insects, honeydew; usually not indoors **Nest Sites:** large mounds that only reach grass height which causes some confusion with fire ants; also under rocks, landscape timbers, firewood, etc. **Life cycle:** mating flights in spring/summer	Granular ant baits (not baits with oils as attractant), or drench or other individual mound treatments.
Carpenter ants, *Camponotus sp.* 	**Nodes on waist:** one **Gaster tip:** circular opening **Worker size:** relatively large, 1/8 - 5/8 inch **Shape of thorax:** evenly rounded **Color:** black, black and red, golden, etc. different for each species	**Foraging:** most occurs at night, living and dead insects; honeydew **Nest Sites:** firewood, moisture-damaged wood, insulation, trees, fences, etc. **Life cycle:** Mating flights resulting in single-queen colonies in Tenn.	Locate nest and treat, bait where activity found or apply a nonrepellent to a foundation base and where ants are entering. See Chapter 10 in this manual for more details. Remove conducive conditions.

Table 4-1. Quick reference guide to ant identification and control. Information on sanitation, pest-proofing, monitoring and mapping, essential components for an ant management program, can be found in the text prior to this table.

Pest	Pest identification	Behavior/Damage	Management
Crazy ants, *Paratrechina sp.* 	**Nodes on waist:** one **Gaster tip:** circular opening **Worker size:** 1/8 inch **Shape of thorax:** uneven **Color:** usually dark **Other:** first antennal segment long, sometimes twice as long as head, legs long; fast-moving	**Foraging:** insects, grease sweets, soda, honeydew, seeds; may forage long distances up to 100 ft. **Nest Sites:** opportunistic nesters in cracks and crevices in moist or dry environments such as soil under logs, stones, timbers, trash, etc. **Life cycle:** multiple queens; reproduce through budding and mating flights	They are omnivorous, but difficult to attract to ant baits. Correct conducive conditions, locate and treat colonies and use a perimeter treatment to keep subsequent colonies form entering.
False honey ant or winter ant, *Prenolepis imparis* 	**Nodes on waist:** one **Gaster tip:** circular opening **Worker size:** 1/8 inch **Shape of thorax:** figure-eight shaped when viewed from above **Color:** red-brown to black with red; gaster darker than head and alitrunk	**Foraging:** most obvious in cooler times of the year; forages from 40 to 65 F; feed on sweets, meats, insects and honeydew which expands the abdomen into a heart shape which may cause confusion with acrobat ants **Nest Sites:** nests in soil or under objects in dark or shaded areas such as woodlands **Life cycle:** mating flights	Locate colony and inject mound or try a liquid sweet bait.
Little black ant, *Monomorium minimum and other spp.* 	**Nodes on waist:** two **Gaster tip:** sting **Worker size:** 1/16 inch **Antennae:** 12-segmented antennae with a three-segmented club **Color:** black	**Foraging:** insects, honeydew produced by sucking insects such as aphids, sweets, meats, bread, grease, oils, vegetables and fruits. **Nest Sites:** in soil, under logs, stones, indoors in rotten wood, woodwork or masonry **Life cycle:** Reproduction occurs through mating flights and possibly "budding".	Common pest found around homes in Tennessee. Bait indoors. Nests often located outdoors. If so, can treat individual mound or bait.
Pharaoh ant, also called "sugar ants" or "piss ants," *Monomorium pharaonis* 	**Nodes on waist:** two **Gaster tip:** sting **Worker size:** 1/16 inch **Antennae:** 12-segmented antennae with a three-segmented club **Color:** yellow or orange with the end of the abdomen darkened	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. **Foraging:** insects, honeydew produced by sucking insects such as aphids, sweets, meats, bread, grease, oils, vegetables and fruits. **Nest Sites:** nests rarely found outdoors; however, almost any indoor crack and crevice close to sources of warmth and water (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. **Life cycle:** 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. Hundreds of queens and 10,000 - 100,000s workers may be present.	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. Give a test taste of all baits. Prebait entire structure with honey and natural peanut butter. Place a bait wherever ants are found.
Black imported fire ant, *Solenopsis richteri*, Hybrid, *Solenopsis invicta x Solenopsis richteri*, Red imported Fire ant, *Solenopsis invicta* 	**Nodes on waist:** two **Gaster tip:** sting **Worker size:** 1/8 to 1/4 inch. Queen ants 3/8 inch and lose their wings after mating. **Antennae:** 10-segmented antennae with a two-segmented club **Color:** reddish brown to dark brown	**Foraging:** most occurs between 70 and 90F, primarily eat insects and other invertebrates, also nectar, oils, seeds, dead animals **Nest Sites:** Mounds up to 2 ft. high are built in open areas although they occasionally nest indoors and in such structures as utility housings and tree trunks. Currently 49 southern Tenn. counties quarantined. **Life cycle:** Single queen colonies in Tenn. except Williamson County. Mating flights occur on a warm day after a rain. Brood and queen move within the mound in response to temperature.	In general, use the two-step method. Broadcast a bait and seven to 10 days later treat mounds in high traffic areas with an individual mound treatment. Several publications (SP419, The Two Step Method: Managing Fire Ants Around Homes and Neighborhoods and PB-1739 Managing Fire Ants in Urban Areas) are available from your local county Extension agent or at http://fireants.utk.edu. Treating in the landscape may require a category 3 certification.

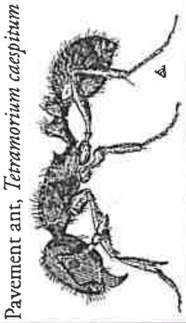
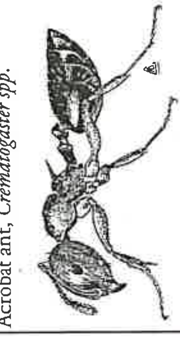
Pest	Pest identification	Behavior/Damage	Management
Pest	**Pest identification**	**Behavior/Damage**	**Management**
Pavement ant, *Tetramorium caespitum* 	**Nodes on waist:** two **Gaster tip:** sting **Worker size:** 1/8 inch **Shape of thorax:** a small pair of spines on the propodeum, narrow, parallel furrows in the head and thorax **Color:** brown to black	**Foraging:** meat, grease, dead insects, seeds and sweets **Nest Sites:** soil beneath stones, pavement or slabs; indoors in walls, under floors or in insulation. **Life cycle:** Swarms from outside nests occur in the spring, but may occur continuously if the nest is located indoors.	Baiting is effective for this ant. 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.
Acrobat ant, *Crematogaster spp.* 	**Nodes on waist:** two-segmented waist that is attached to the top of the gaster; may hold their heart-shaped abdomen up over their bodies. **Gaster tip:** sting **Worker size:** about 1/8 inch **Shape of thorax:** spines on the thorax **Color:** brown to black, varies	**Foraging:** honeydew produced by aphids and proteins **Nest Sites:** in logs, stumps or tree trunks or other dead wood, and occasionally indoors in insulation board, roofing, damp wood and wood previously infested by ants or termites. **Life cycle:** single queen colonies formed by mating flights	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.
Big-headed ants, *Pheidole* spp. 	**Nodes on waist:** two **Gaster** tip: sting **Worker size:** Two sizes of workers. Major worker ants have a relatively large head compared to their bodies. **Antennae:** 12-segmented antennae with a three-segmented club **Shape of thorax:** spines on the thorax **Color:** yellowish-red to reddish-brown	**Foraging:** live and dead insects, seeds and honeydew outdoors and greasy food sources and sweets indoors. **Nest Sites:** in soil under rocks, logs, firewood, timbers, mulch or grass **Life cycle:** single or multiple queens; swarms or budding	Correct conducive conditions, locate and treat colonies, otherwise bait, and use a perimeter treatment to keep subsequent colonies form entering.

Table 4-1. Continued.

try a taste test by offering several different baits and seeing which is most attractive to the pest ant.

Research has shown that insect growth regulators, such as methoprene, 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 very effective when dealing with large structures, such as hospitals, with extensive infestations.

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

- Sprays may kill the foraging population, and the bait will not be brought back to the nest.
- 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, sprays of fast-acting insecticides 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 fast-acting sprays and exploit the foraging ants to bring the baits back to inaccessible nests.

If ants are still present several weeks after the initial baiting, then monitoring and subsequent baiting should be performed again. Liquid baits may be consumed quickly and may need to be replenished often. 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 the bait more effective by removing or denying access to 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 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 a foraging trail disappears into the wall, but this may not lead to the nest. Dust formulations are preferred for treating nests indoors because they do not stain, generally give longer residual control than sprays and will fill a void. Apply dusts sparingly in thin, even layers in the ant nest area.

If nests are located outdoors, see Extension *PB-1739 Managing Imported Fire Ants in Urban Areas* for information on individual mound treatments (baits, drenches, granules, dusts, aerosols or excavation), broadcast baiting and surface applications. Mounds should not be disturbed prior to treatment.

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.

Barrier treatments can greatly reduce or eliminate ant invasion into the home. In general, pesticides applied to the perimeter of the structure are permissible under a category 7 certification and GRC license. Pesticide application made to the landscape and lawn require the applicator to have a category 3 certification and work under the supervision of an operator licensed in HLT.

New nonrepellent insecticides have effectively reduced perimeter pest ants populations both indoors and outdoors when combined with a liquid bait in the landscape. Technically, this spray application is not a barrier treatment because it does not initially stopping ants from entering. Ants cross the treatment zone and die much slower than ants that would have contacted most pyrethroids.

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.

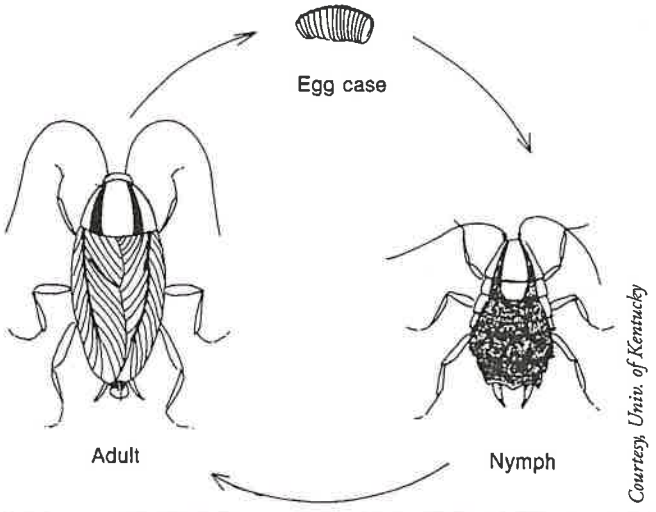


Figure 4-2. Cockroach life cycle.

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. Exposure to cockroaches, their excrement and cast-off skins may result in allergic reactions, such as wheezing, watery eyes, and skin rashes or could trigger an asthma attack. While cockroaches thrive where sanitation is poor, even the cleanliest home or restaurant can become infested.

Cockroaches enter buildings through produce boxes, beverage cartons, or grocery bags; larger roaches gain entry through cracks and openings around windows, doors, and pipe penetrations and through sewer and drain lines.

Cockroaches are flattened, brownish, fast-running insects, with long, slender antennae. There are three life stages: egg, nymph, and adult (Figure 4-2). 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. Species such as the German cockroach are capable of producing several thousand offspring in less than a year.

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 which 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 man. 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 (Table 4-2). Determining which type of cockroach is present is essential in knowing where to focus your control efforts. The descriptions provided in the table will help you identify common cockroach species.

Cockroach Management

Cockroach management is based on inspection/monitoring, sanitation, exclusion, chemical control and further evaluation.

Inspection/Monitoring. Since cockroaches may be hiding in many places, a thorough inspection is essential to locate as many of these areas as possible. A bright flashlight, inspection mirror (for inspecting underneath, above and behind construction elements), and a set of screwdrivers and pliers to access equipment and other potential hiding places, are essential tools for conducting a professional cockroach

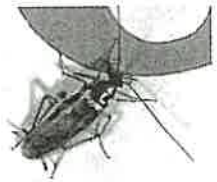
Pest	Pest Identification/Life Cycle	Behavior/Damage	Comments
German cockroach, *Blattella germanica*  *Courtesy, Univ. of Florida*	**Size:** adults are 1/2 inch - 5/8 inch **Color:** adults are light brown with two dark stripes running lengthwise along the pronotum or shield-like area behind the head. The nymphs are smaller and darker with a tan stripe down the middle of the back. **Egg case:** carried until 24 hours before hatch; contains 30 and 40 eggs **Adult longevity:** about 180 days **Life cycle:** German cockroaches reproduce very rapidly, which is one reason control can be difficult. At 76F, development from egg to adult may range from 36 - 215 days with an average of 103 days. A single mated female can produce 4 to 5 egg cases and an infestation of several thousand new roaches.	**Foraging sites:** kitchens, bathrooms, and eating areas. They often travel between rooms or adjoining apartments along utility pipes and wires and within wall voids. **Harborage sites:** 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.	The is by far the most common and important cockroach species from the standpoint of public health.
Brown-banded cockroach, *Supella longipalpa*  *Courtesy, Clemson Univ.*	**Size:** 1/2 inch **Color:** light brown two transverse yellow bands across the base of the wings. **Egg case:** pea-sized egg capsules (10 - 18 eggs) glued to hidden surfaces, such as the undersides of dressers and tables; 70 days to hatch.	**Food/foraging:** feed on starchy materials and may be found anywhere in a building. **Harborage sites:** 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.	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.
American cockroach, *Periplaneta americana*  *Courtesy, Univ. of Florida*	**Size:** adult about 1 1/2 inches **Color:** reddish brown to brown, with a pale yellow band around the edge of the shield behind the head. Adults have well-developed wings, but seldom fly. Cerci long and pointed. Nymphs are smaller and lack wings, but are otherwise similar to the adults. **Life cycle:** The developmental rate of the American cockroach is much slower than the German cockroach, usually requiring more than a year from egg to adult. **Egg case:** About 15 eggns per capsule; egg case deposited on or near food; hatches in about 60 days.	**Food/foraging sites:** sweet, starchy and other organic material **Harborage sites:** 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.	Largest cockroach found in Tennessee.

Table 4-2. Quick reference guide to cockroaches.

Pest	Pest Identification/Life Cycle	Behavior/Damage	Comments
Smokybrown cockroach, *Periplaneta fuliginosa*  Courtesy, Univ. of Florida	**Size:** adult about 1 - 1 1/2 inches **Color:** uniform, very dark brown to black; head shield is a solid, dark color. **Life cycle:** The developmental rate of the smokybrown cockroach is much slower than the German cockroach, usually requiring about a year or more from egg to adult. **Egg case:** About 24 eggs per capsule; deposited on surfaces and camouflaged with debris from environment.	**Food/foraging sites:** Not a particularly mobile species, tends to return to preferred harborage. **Harborage sites:** in moist, warm and dark places like tree-holes, mulches, soffits in attics with poor ventilation. Needs access to water every three days or so. Primarily an outdoor pest, but when found indoors check locations with a stable relative humidity such as attics.	Indoor and outdoor pesticide applications often needed to achieve long-term control.
Oriental cockroach, *Blatta orientalis*  Courtesy, Clemson Univ.	**Size:** 1 - 1 1/4 inch. Females have very short wing pads; males have wings that cover about half the abdomen, but never exceed the end of the abdomen **Color:** shiny black or dark brown, **Life cycle:** The entire life cycle may require one to two years. **Egg case:** deposited in moist places; 12 - 16 eggs/case; takes about 60 days to hatch.	**Food/foraging sites:** decaying organic matter **Harborage sites:** 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 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.	Slow-moving roach.

Table 4-2. Continued.

inspection. Look for living and dead cockroaches, cast skins, egg capsules and droppings, all of which aid in identification. The use of a flushing agent, such as pyrethrins or forced air, irritates or flushes cockroaches into the open. 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.

Sticky traps and glue boards are useful tools for pinpointing areas where cockroaches may be hiding. These 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.

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 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 set 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. 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. An emphasis should be placed on finding and treating cockroach harborages, RATHER than treating along baseboards, wall coverings, 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.

Baits are the most widely used formulation for managing cockroaches. 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. Baits are often 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.

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, and storage areas 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. Use glue board and visual inspections to help determine if treatment is necessary. After a cockroach control program begins, evaluate the effectiveness of the methods. 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 elimination 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.

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. 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.

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.

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 4-3). Optimum larval development requires that the breeding medium be moist, but not wet. 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 Table 4-3. 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.

Sanitation. 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.

Promptly removing waste ensures that if flies do begin breeding in garbage, they will be removed before a new generation reaches the adult stage. Good sanitation practices include:

- Cleaning garbage cans and dumpsters regularly and keeping them covered to prevent attracting flies.
- Collecting trash at least twice a week from residences, and daily from business establishments.

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.

Exclusion. 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.

Traps. 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. In order for these traps 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.

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.

Non-Residual (Contact) Sprays — Temporary control of adult flies can be achieved by applying synergized pyrethrins or short-residual synthetic pyrethroids such as resmethrin.

Fly	Identifying Characteristics	Habitat	Life Cycle	Management
House fly  Courtesy, Univ. of Florida	4 dark stripes on thorax, 1/4 inch long	Garbage, all types of waste, pet feces	1 - 2 weeks 6 - 10 days	Sanitation, exclusion, habitat destruction, residual and contact sprays, baits, traps and larvicides.
Flesh flies  Courtesy, Univ. of Florida	3/8 - 9/16 inch long. 2 - 3 times larger than house flies. Black and gray checkered pattern on abdomen, 3 dark stripes on the thorax.	Decayed flesh and spoiling meat, animal carcasses, waste, manure, garbage and wounds in living animals	2 - 4 weeks 8 - 21 days	Sanitation, habitat destruction, residual and contact sprays, and larvicides

Table 4-3. Important filth flies of urban environments.

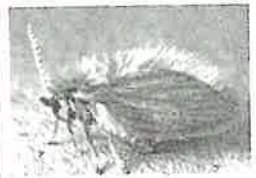
Fly	Identifying Characteristics	Habitat	Life Cycle	Management
Blow flies  Courtesy, Univ. of Florida	About 1/2 inch long — may be 2X size of house fly. Metallic blue, green or black thorax.	Animal carcasses, waste, manure, garbage	2 - 4 weeks 9 - 21 days	Locate and remove animals carcass, other sanitation, and habitat destruction, residual and contact sprays
Fruit Flies  Courtesy, Univ. of Florida	Small flies. 1/8 inch. Eyes sometimes red, yellowish-brown bodies.	Decaying fruits and vegetables, bottoms of uncleaned garbage cans	1 - 2 weeks 9 - 12 days	Sanitation and habitat destruction, traps, residual and contact sprays
Phorid flies (Humpbacked flies)  Courtesy, Univ. of Florida	Small (1/8 inch). Similar to fruit flies in size, but are black and have humpbacked thorax	Decaying vegetable and animal matter	1 - 2 weeks 10 - 25 days	Sanitation and habitat destruction, moisture control, residual and contact sprays
Drain flies (Moth flies)  Courtesy, UT Ext-PP	Small (1/16 - 1/8 inch). Body and wings covered with hair. Wing veins parallel.	Decaying vegetable and animal matter in uncleaned drains, around kitchen or bathroom sinks, moist plant litter, garbage and sewage	2 - 3 weeks 7 - 20 days	Sanitation, habitat destruction and moisture control, residual and contact sprays
Cluster Flies  Courtesy, Univ of Minnesota	Resemble house flies, but slightly larger (5/16 inch); yellow hairs on thorax near head; wings overlap at tips when at rest; sluggish movement. May overwinter in attics and walls.	Larvae parasitic on earthworms	4 - 6 weeks 27 - 39 days	Exclusion such as sealing and caulking around eaves, etc., residual and contact sprays

Table 4-3. Important filth flies of urban environments.

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 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).
- *Fly Baits* — Baits are a mixture of toxicant and attractant and are used primarily to control house flies. Some 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.

Review Questions

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

2. 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

3. Cockroaches need _____ to be successful.
   - A. food, moisture, harborage
   - B. food, moisture, open spaces
   - C. warmth, food, open spaces
   - D. cracks, crevices, food

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

5. _____ are the most widely used formulation for cockroach control.
   - A. Emulsifiable concentrates
   - B. Dusts
   - C. Wettable powders
   - D. Baits

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

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

8. When baiting for ants indoors, applying persistent, fast-acting, contact insecticides does not affect the baiting success.
   - A. True
   - B. False

9. 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

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

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

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 hemipterans (the true bugs), fleas, lice, ticks, midges and some mites. Biting or stinging arthropod 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. To control mosquitoes on public lands and public waters, you must be certified in category 8 and under the direction of someone licensed in Public Health Mosquito Control (PHM).

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.

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 medical concern because they are able to transmit dog tapeworm, *Dipylidium caninum*.

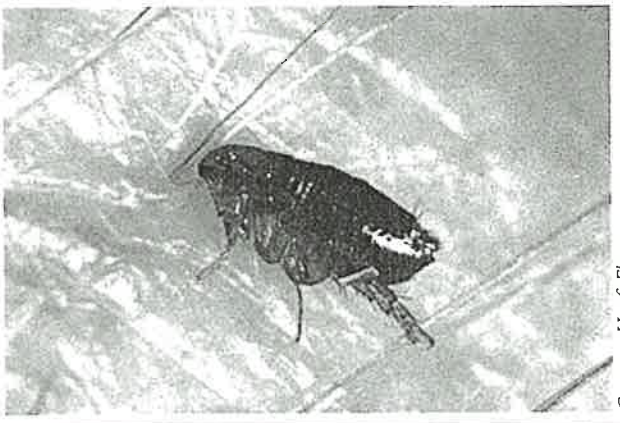
Fleas are obligate ectoparasites, meaning they must stay on or close to a host to survive. Cat flea hosts include cats, dogs, opossums, foxes, occasionally rats and other urban animals. Although adult fleas prefer to feed on dogs, cats or other small animals, they will attack humans when pets are not 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 which would hold them to the pet's hair. This explains why most fleas are found where the pet rests.

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



Courtesy, U. of Fla.

Figure 5-1. Cat flea adult.

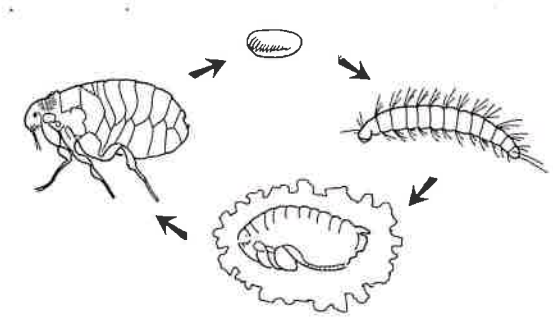


Figure 5-2. Cat flea life cycle.

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 pre-emergent adult waits for a stimulus which causes it to emerge. Such stimuli can include pressure, vibration or heat, which indicates the presence of a host.

The male and the female feed with their sucking mouthparts and mate on the host. 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

Vacuuming areas frequented by pets provides many benefits to those stricken with fleas. Vacuuming:

- removes 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.
- removes organic matter and fecal blood the larvae need for food to mature.
- stimulates 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.
- straightens the carpet fibers so that if an insecticide is applied it will penetrate to the carpet base where the larvae are found.

It is important to dispose of the vacuum cleaner bag immediately after use in an outside garbage can with a tight-fitting lid. Steam cleaning will kill most of the fleas, including those in cocoons, as well as removing larval food.

Steps for a Chemical Flea Control Program

With veterinarian supplied products that are currently available, control of fleas in small- to moderate-sized infestations is likely to occur by clients using those pet treatment products alone. Two months may be needed to completely break the flea life cycle. If client pet treatment alone does not provide sufficient control, initiate a complete control program by April.

The following measures should be performed on the same day to maximize flea control success.

Step 1. Ensure the pet is treated. Adult fleas spend most of their life on the animal — not in the carpet. Untreated pets will continue to be bothered by fleas and will bring fleas in from outdoors.

Step 2. Vacuum infested areas twice a week and prior to treatment to remove eggs, larvae, adults and organic matter. Steam cleaning the carpet will also reduce populations.

Step 3. Treat pet resting areas indoors and clean or remove pet bedding on the same day. Insect growth regulators are important to break the flea life cycle. A combination of an insect growth regulator and an adulticide may be the most efficient formulation to use.

Step 4. Mow grass, keep weeds down and trim shrubs to expose flea eggs and larvae to lethal dessication. Irrigating areas surrounding buildings, but not against buildings, may kill fleas by drowning. If fleas are surviving outdoors, apply an approved insecticide to labeled areas.

Keep pets and people out of treated area (indoors and outdoors) until spray dries. Follow precautionary statements about pesticides staining carpets.

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, saclike 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 and molt to the eight-legged nymph after they are full of blood. 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 one-half inch.

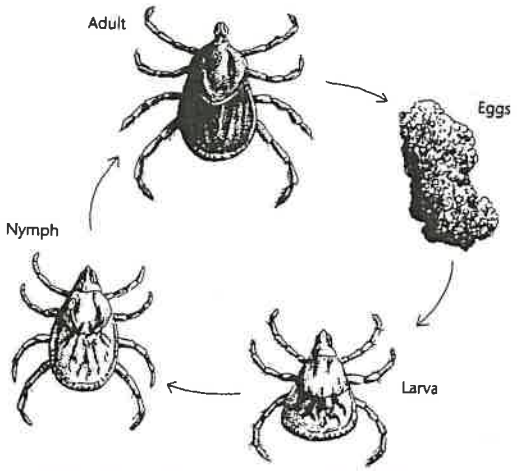


Figure 5-3. Tick life cycle.

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).

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 organism that causes Rocky Mountain Spotted Fever (RMSF) 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, but may sometimes be found on porches, in backyards or other sheltered places frequented by dogs. It is usually found in the spring and summer.

Diseases Transmitted by Ticks in Tennessee

Rocky Mountain Spotted Fever is a rickettsial disease that is the most common tick-transmitted disease in Tennessee. One hundred and seventy five cases were reported in Tennessee from 1994 - 1998. 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 newer disease, which 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 symptoms may include a characteristic "bull's-eye" rash as well as fever, malaise, fatigue, headache, muscle aches and joint aches. Lyme Disease is most often encountered in the New England states, the upper Midwest, mid-Atlantic states and California. Check the CDC Lyme Disease Home Page (http://www.cdc.gov/ncidod/dvbid/lyme/index.htm) for updates on Lyme disease incidence in Tennessee.

Removal of the 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.

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

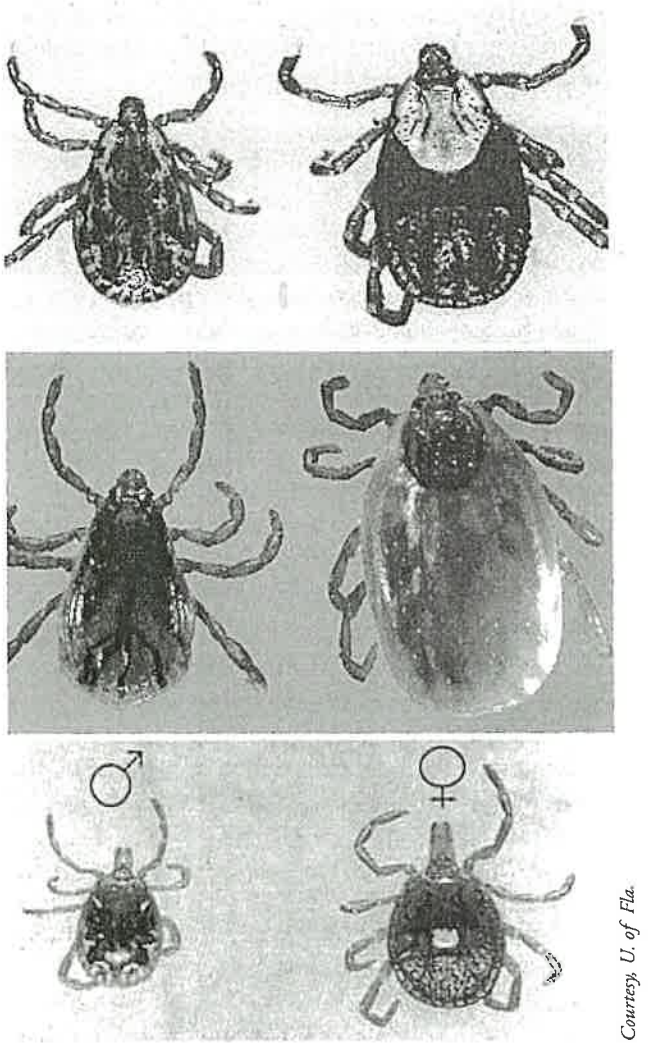


Figure 5-4. Top to bottom: American dog tick, brown dog tick and lone star tick.

environment so it is less conducive to tick survival and if necessary, applying pesticides to pets and areas frequented by 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 person licensed in HLT.

Nonchemical methods for reducing tick problems include mowing the lawn and controlling weeds. 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.

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, floors, furniture, baseboards and behind furniture. Insecticidal spray or dusts 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.

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 are about the size of a period at the end of a sentence and live on the host or in their nests, but migrate to other areas of the structure when the animal dies or abandons the nest. Other mites that may attack people are chiggers and human itch mite or scabies.

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. 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. A vacuum cleaner or moistened cloth can be used to eliminate mites crawling on open surfaces.

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 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 the fecal smears and blood spots visible on pillowcases, sheets and mattresses. Heavy infestations of bed bugs may be accompanied by a distinct, raspberry-like odor.

To control bed bugs, caulk, or otherwise repair all cracks and spaces behind baseboards and other areas of the house. Treat infested areas with a crack and crevice or void application of a dust (or liquid, if appropriate) insecticide registered for this purpose. Treat crevices of bed frames, baseboards, under edges of wall-to-wall carpeting, other wall/floor material interfaces, closets, wood paneling, and the back side of wall-mounted items, behind mounted light and ceiling fan fixtures and other places that may harbor bed bugs. Avoid spray runoff if applying liquid insecticides onto surfaces and into cracks. Do not apply liquids to electrical components. Multi-dwelling structures and hotels require frequent inspections and perhaps repeated applications. If the infestation is localized in an apartment building or hotel, treat all units connected to the infested area.

Because of the safety risk involved with treating mattresses, sofas or other furniture which people contact, alternative methods may be employed. Orkin (Meek 2003) has data that indicates steam cleaning, in conjunction with applying

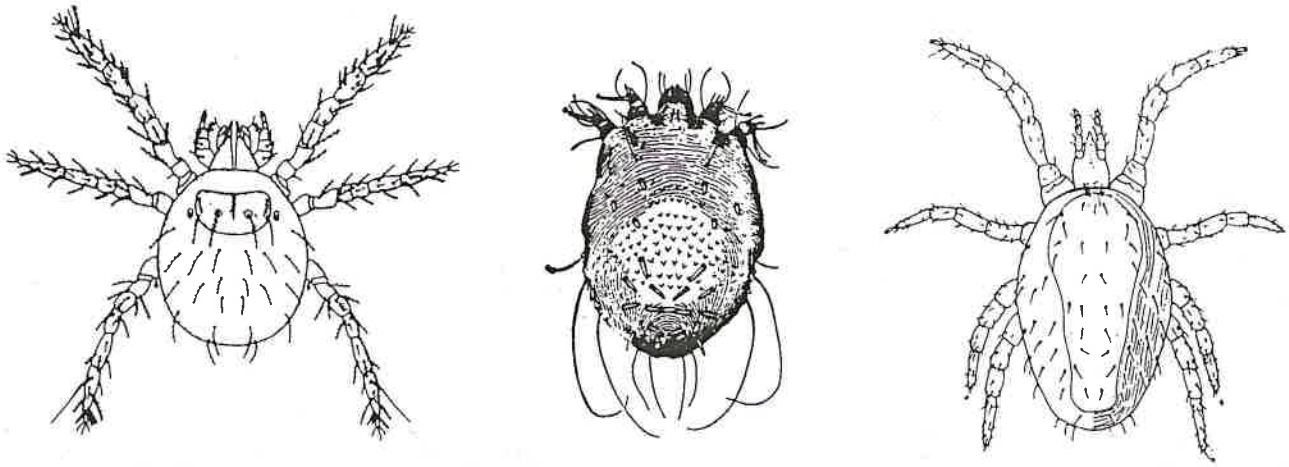


Figure 5-5. Some mites (left to right; chigger, scabies and bird or rodent mite) that may attack humans.

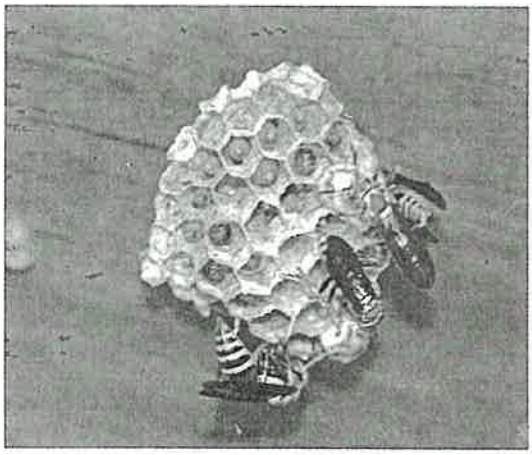
Courtesy, UT Ed-PP

Figure 5-6. The bed bug.

an insecticidal dust to suspected crevice and void harborages, can be very effective in managing bed bug populations. A low vapor, high temperature (220F) steam applied to seams, tufts, button holes, crevices and folds of mattresses, box springs, sofas, love seats, chairs and other similar furniture should kill all eggs, nymphs and adult bed bugs contacted. Check sofas for mattresses. Vacuuming with a crevice tool along edges of the beds, mattresses, etc. can also aid reduction in bed bug populations.

Wasps, Hornets and Yellowjackets

Wasp, hornet and yellowjacket 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 yellowjackets 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, can be dangerous and result in multiple stings.



Courtesy, UT Ed-PP

Figure 5-7. Paper wasp nest.

Types of Wasps

Paper Wasps. Paper wasps (as well as hornets and yellowjackets) 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 yellowjackets or hornets and can be eliminated rather easily with a wasp and hornet spray aerosols. 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 and yellowjackets. 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 which are extremely aggressive when disturbed. The nests are often located out of reach.

Yellowjackets (Figure 5-8) 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. Fall mated queens overwinter under bark and in other sheltered locations. In the spring the queens emerge and construct a small paper nest in which they lay their 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 male and female reproductives 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, as well as, in walls, attics, crawl spaces and behind the siding of buildings. See *SP341-M Yellowjacket Wasps in Tennessee* available from your county Extension agent or at the Extension Web site (Appendix) for more information on the species of yellowjackets found in Tennessee.

Treat hornet (except European hornet) and yellowjacket nests in the spring and at night when most wasps are within

Courtesy, P. Parkman, UT Ed-PP

Figure 5-8. Yellowjacket adult.

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 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 *SP290-A European Hornets Tapping at Your Window at Night* from your county Extension office or Web site 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 yellowjacket colonies die naturally after the weather turns cold and the paper carton disintegrates over the winter months. Only fall mated queens survive the winter.

Foraging yellowjackets

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. If nests can't be found and treated, here are some control options.

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.
- 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.

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.

Traps: Although only of marginal benefit, traps are available which 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.

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 nonthreatening 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 ½ inch long, shiny black and usually has a red hourglass mark on the underside of the abdomen (Figure 5-9). 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.

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 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.

Courtesy, U. of Fla., and UT Ext PP

Figure 5-9. Black widow adult. Immatures and males may have red dots on the upper abdomen (inset).

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% 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 absorption of venom. Victims should seek medical attention promptly. An antivenom is also available for severe cases.

Remove trash, old boxes, piles of lumber, old rubble piles and other unwanted items from under or around houses and outbuildings. Do not go barefoot or handle firewood without gloves. Install screens on doors and windows to prevent entry. Seal or caulk cracks and crevices where spiders can enter the house. Wash off the outside of the house or building, especially around window wells and other undisturbed places where webs are built. Spiders are fragile and easily damaged, so sweeping with a stiff broom, or web removing device such as the Webster, will remove webbing and usually kill them.

Because black widow spiders spend most of the time in or on webbing, thorough applications of insecticides that contact spiders in their webs may cause quicker population reduction. Residual crack and crevice sprays applied where spiders can hide and enter buildings, are helpful. Outdoors, spray around the perimeter of buildings using formulations that will not damage plants and treat under patios and decks if the house is of pier and beam construction.

Brown Recluse Spider. The brown recluse spider (Figure 5-10) is one of the feared poisonous spiders occurring in Tennessee and occurs in every county in Tennessee with the possible exception of a few extreme eastern counties. 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.

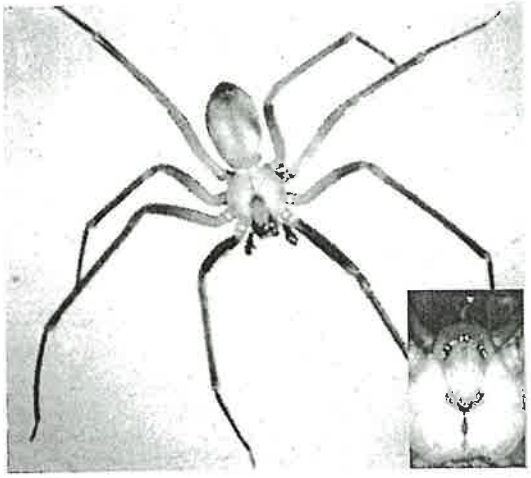


Figure 5-10. Brown recluse spider. Insect shows three pair of eyes arranged in a semi-circular pattern.

The brown recluse *Loxosceles reclusa* is a medium-sized spider. The adult body ranges from 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. The second pair of legs are longer than the remaining pairs in both sexes. A violin-shaped marking is present on the carapace (the top of the body directly above the legs). 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.

Brown recluse spiders prefer sheltered areas with low moisture levels. They have been found under loose bark, in hollow logs and under stones. In homes, they tend to prefer darkened storage areas in closets, garages, basements, attics, cupboards and other seldom disturbed and sheltered places.

Brown recluse spiders feed on a variety of insects, other arthropods and occasionally a spider. The spider is alerted to the presence of prey by web vibrations caused by passing prey and may forage short distances from the web at night.

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. Case reports of blood abnormalities, kidney failure or death have been reported.

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:

- store clothing in sealed plastic bags or storage boxes,
- store shoes in plastic shoe boxes,
- shake clothing and shoes before wearing,
- move beds away from walls or curtains,
- place glue boards under bed posts,
- remove bed skirts from box springs,
- do not use bedspreads that touch or come close to the floor and
- 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.

Monitoring: Use monitoring traps, often called 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.

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.

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.

Exterior Treatments: Removing harborage sites will reduce spider populations outdoors. Cracks in exterior walls should be treated with an insecticidal dust mentioned above and then sealed.

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. See *PB1191 Brown Recluse Spider* available from your County Extension agent or at our Web site (Appendix).

Mosquitoes

Mosquitoes have done more harm to human health and well-being than any other insect group. They are the only natural carriers of organisms that cause debilitating diseases such as malaria, yellow fever, dengue, and several types of viral encephalitis. Mosquitoes can also transmit filarial diseases (caused by parasitic worms) to humans and animals. The viral encephalitides and dog heartworm are the only diseases that are a perennial threat in Tennessee. The mosquito's annoying biting habits often make it a nuisance around the home, and in parks and other recreational areas. Fortunately, most mosquito species feed on animals other than humans. However, some of these species can be pests of pets and farm animals.

Tennessee has over 52 mosquito species. Only the female mosquito bites; males feed strictly on nectar and other plant juices. Female mosquitoes need an additional source of protein (in the form of a blood meal) before they can develop eggs. Females also feed on nectar and plant juices, using this food source for flight and metabolism.

Biology and Habits

Mosquito development consists of four stages: egg, larva, pupa, and adult. All immature life stages are aquatic. Mosquitoes are generally small (less than 1/2 inch) and fragile. Their most obvious characteristics include one pair of wings with scales on the wing veins and hind margin, and an elongated beak with piercing mouthparts (Figure 5-11). Mosquitoes are often confused with midges, punkies, biting gnats, and other flies.

Courtesy Univ. of Fla.

Figure 5-11. *Aedes albopictus.* The Asian Tiger mosquito.

Eggs. Mosquito eggs, elongate and about 1/40 inch long, turn dark brown or black when ready to hatch. Eggs are laid singly or in batches of 50-400. *Anopheles* and *Aedes* deposit eggs singly, *Culiseta* and *Culex* spp. deposit them in rafts. Oviposition by most groups is on the surface or along the margins of quiet pools of water. However, flood water and salt marsh mosquitoes, as well as many tree-hole breeders, (e.g., *Aedes* and *Psorophora*) oviposit above the waterline in sites subject to flooding by tidal water, overflow, or rainwater. Each mosquito species lays its eggs in a specific type of habitat.

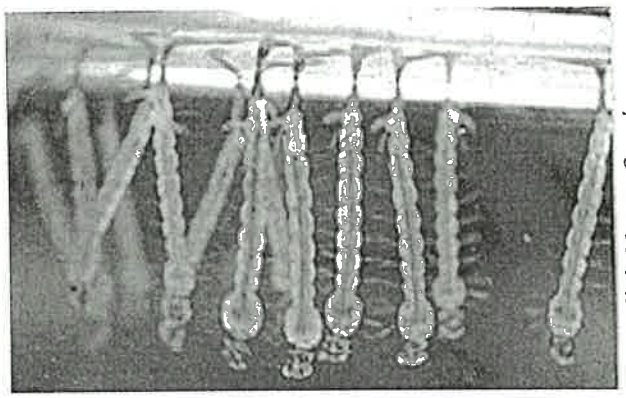
Eggs laid by floodwater mosquitoes do not all hatch at the same time. Most hatch after the first flooding, the remainder will emerge only after the second or subsequent floodings. Eggs of some common species will hatch only after 4 years of intermittent flooding.

Larvae. Mosquito larvae are commonly known as "wigglers," because of their swimming habits. They differ from other aquatic insects by an absence of legs and by their bulbous thorax, which is wider than the head or abdomen. In contrast to other fly larvae, most larval mosquitoes have a complete head capsule and a prominent breathing tube located on the eighth abdominal segment (Figure 5-12). This stage lasts about 7 days, depending on temperature.

Mosquito larvae can be found in virtually any naturally occurring collection of water. Great swarms may be produced from either fresh or brackish water, polluted or clear. Breeding sources may include water in tin cans, vehicle tires, hoof prints, tree holes, leaf cups, or the margins of rivers, streams, lakes, or impoundments. Mosquito larvae cannot occur, however, in large bodies of water with clean edges because the larvae are unable to withstand wave action.

Most wigglers hang suspended diagonally from the water surface by means of the breathing tube. *Anopheles* larvae do not have a tube, however, and lie horizontally just beneath the surface of the water by means of float hairs. Mosquito larvae are quite mobile and will quickly dive to the bottom if disturbed. They will return to the surface shortly.

Most mosquito larvae feed by filtering out microorganisms and other particulates in the water, or by "browsing" microorganisms growing on solid surfaces. Some mosquitoes,



Courtesy, Clarke Mosquito Control

Figure 5-12. Mosquito larvae.

including *Toxorhynchites* species, are considered beneficial insects because the larval stage actively preys on other mosquito larvae.

Pupae. Mosquito larvae molt 4 times. The last results in a non-feeding pupa or "tumbler." The pupal stage is quite short, usually 2-3 days. The pupa is shaped like a comma (Figure 5-13). The "dot" part of the comma is called the cephalothorax and the "tail" of the comma is the abdomen. A pair of breathing "trumpets" are situated on top of the cephalothorax and paddle-like flaps occur on the end of the abdomen. The pupa is remarkably active and sensitive to disturbances. When alerted, it quickly darts in a tumbling action to deeper water and, after a few moments, rises with little motion back to the surface. Pupae are aquatic, but they can survive quite well on a moist substrate such as wet mud in a drying puddle.

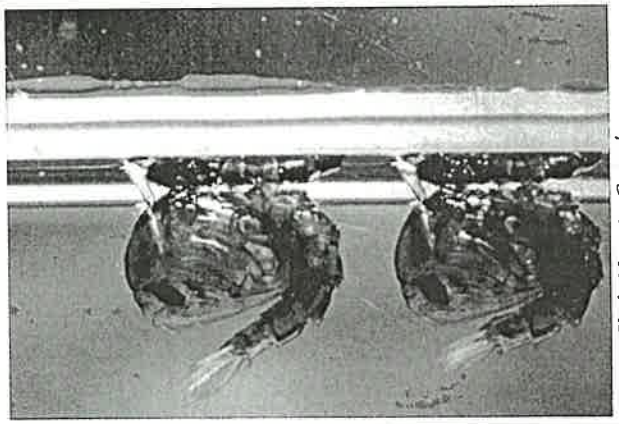
Adult. The adult mosquito emerges from the pupal case onto the surface of the water. Careful movements by the emerging adult are required to ensure that it does not fall sideways and become trapped in the surface film.

Male mosquitoes usually live no longer than 1 to 2 weeks. Females with ample food may live for several months although, during the summer, female survival may average closer to two weeks. Some mosquito species have only one generation each year. Other species may have four or more generations per year, with populations building up to large numbers by late summer.

Some species can fly no more than a few city blocks, whereas others can travel up to twenty miles. Most mosquitoes are active only at night, although some bite during the daytime. When they are not active, adult mosquitoes tend to seek protection in quiet areas with high humidity. Resting sites for adult mosquitoes include shrubs, wooded areas, and similar dense vegetation, drainage ditches, sewers, or under the eaves of buildings.

Mosquito Species Common in Tennessee

Only trained specialists can differentiate between mosquito species. Knowing which species is involved is crucial to planning appropriate control measures. See Table 5-1 for some of the most troublesome species found in Tennessee. A key to mosquitoes found in the Tennessee Valley can be found in *PB1685 Public Health Pest Control: Tennessee Mosquito Control Handbook Licensing Manual* (http://eppserver.ag.utk.edu/pat/PATinfo/training/Manuals.htm)



Courtesy, Clarke Mosquito Control

Figure 5-13. Mosquito pupae.

Aedes albopictus, the Asian tiger mosquito, was first discovered in 1985 in the Houston, Texas, area in used tires imported from Japan. It has spread rapidly throughout the eastern U.S. where it is now reported in 25 states and is established throughout Tennessee. The Asian tiger mosquito has the potential to become established throughout much of the U.S. because it can survive winter temperatures. It is an aggressive daytime biter and has the potential to transmit numerous diseases including dengue, yellow fever, La Crosse encephalitis, West Nile virus, eastern equine encephalitis, and dog heartworm. La Crosse encephalitis, West Nile virus, and dog heartworm are of particular concern to Tennesseans because the pathogenic agents responsible for these diseases are known to occur here.

The Asian tiger mosquito is of average size, black and white, with banded white legs and a distinctive single white band down the length of the back of the thorax. One of the major larval habitats for the mosquito is artificial containers, principally vehicle tires. The movement and improper storage of used tires is the primary means of dispersal in this country.

Ochlerotatus canadensis, is a dark mosquito with the ends of the legs banded with white. It is a serious pest in woodlands. This species overwinters in the egg stage and is one of the first mosquitoes to appear in early spring. Larvae occur in woodland pools filled by melting snow or spring rains. It prefers pools with bottoms containing dead and decaying leaves, although it is sometimes found in roadside puddles, sink holes and wooded swamps. Eggs are laid singly on the ground above the waterline in woodland pools. Eggs are able to survive long periods of drying. Biting occurs most frequently during the evening hours, but can occur during the day or night.

Ochlerotatus triseriatus, the eastern tree hole mosquito, is black with silvery-white scales at the sides of the thorax. There are no bands on the legs. Larvae are found in tree holes, tires, and other artificial containers. The bites are painful and can be annoying. This mosquito does not fly far from its larval habitat and is the principal vector of La Crosse encephalitis in Tennessee. It has several generations per year and overwinters in the egg stage.

Aedes vexans, the inland floodwater mosquito, is a medium-sized brown mosquito with narrow rings of white scales on

the hind tarsi and a "V"-shaped notch at the middle of each band of white scales on the upper surface of the abdomen. Common larval habitats are rain pools, floodwaters, roadside puddles, and just about all temporary bodies of freshwater. The eggs are laid on the ground above the waterline and hatch when flooding occurs. Adults can fly long distances from their larval sites with flights of ten miles being common. Adults are vicious biters and are especially annoying at dusk and after dark. They rest during the day in grass and other vegetation. This mosquito overwinters in the egg stage.

Anopheles quadrimaculatus. These large, dark-brown mosquitoes have four dark spots near the center of each wing, and the legs are entirely dark. Eggs are laid singly on the water surface with lateral floats to keep them suspended. One hundred or more eggs are laid at a time. This species was the most important vector of malaria in the eastern U.S. and can be found frequently in houses. Their bites are less painful than many other mosquitoes and often go unnoticed. Larval sites are chiefly in permanent, freshwater pools, ponds, and swamps that contain aquatic vegetation or floating debris. City park ponds, sluggish streams, and shallow margins of reservoirs and lakes can contain many larvae. During the day adults rest in cool, damp, dark shelters such as buildings, caves, and under bridges. These mosquitoes feed at night and

SPECIES	HABITAT
Permanent Pool Mosquitoes	
Anopheles punctipennis	lakes, swamps, ditches, stream pools
Anopheles quadrimaculatus	lakes, reservoirs, swamps, ditches
Culex erraticus	lakes, marshes, wetlands
Coquillettidia perturbans	ditches, marshes, swamps, wetlands
Floodwater Mosquitoes	
Ochlerotatus canadensis	shaded depressions
Ochlerotatus sticticus	shaded or open depressions
Ochlerotatus trivittatus	shaded depressions
Aedes vexans	open or shaded pools, ditches
Psorophora ciliata	open depressions, ditches
Psorophora columbiae	open depressions, ditches
Psorophora cyanescens	open depressions, ditches
Psorophora ferox	shaded depressions
Psorophora mathesoni	swampy areas along streams
Container Mosquitoes	
Aedes albopictus	tires, pet bowls, buckets, tree holes
Ochlerotatus triseriatus	tree holes, bird baths, tires
Culex quinquefasciatus	buckets, tires, wetlands rich in organics
Culex salinarius	buckets, tires, wetlands rich in organics

Table 5-1. Seventeen major nuisance species of mosquitoes in the Tennessee Valley, according to type of larval habitat.

will readily enter houses to feed on humans. Cows, horses, mules, pigs, and chickens are also attacked. Adults usually remain within one-half mile of their larval site. Breeding occurs throughout the summer months. Adult fertilized females are the overwintering stage.

Culex quinquefaciatus, the southern house mosquito, is brown, of medium size and has cross bands of white scales on the abdominal segments, but is without prominent markings. It is a vector of St. Louis encephalitis, West Nile virus, and dog heartworm. Larvae occur in rain barrels, tin cans, tires, storm-sewer catch basins, street gutters, polluted ground pools, cesspools and open septic tanks. Eggs are laid on the water surface as rafts in clusters of 100-400. The flight range is restricted unless great numbers are produced. Adults are active only at night and can be found resting during the day in and around houses, out-buildings, and various shelters near their larval places. They commonly enter houses. This mosquito overwinters as an adult. *Culex* spp. are the suspected primary vectors of West Nile Virus.

Mosquitoes and Disease

Mosquitoes are not naturally infected with disease agents; they must first acquire these pathogens from a "sick" individual or host before they can be passed to a "healthy" one. For example, just because a person was bitten by *Anopheles quadrimaculatus* (the mosquito capable of transmitting malaria in Tennessee) doesn't mean that he or she will contract malaria. For that to happen, the mosquito would first have had to have bitten an individual suffering from malaria -- a highly unlikely event in Tennessee.

The following mosquito-borne disease organisms are of some concern in Tennessee.

West Nile Virus (WNV) is a mosquito-borne arbovirus introduced into New York City in 1999 from the Old World. In 2002, there were nearly 4000 reported cases of WNV human infection, with the virus reaching 44 states. In Tennessee, 56 humans, 324 birds, 148 horses and 307 mosquito pools tested positive for WNV in 2002. Mosquitoes are WNV carriers that become infected when they feed on infected birds. Infected mosquitoes can then spread WNV to humans and other animals when they bite. Since 1999, 36 mosquito species have tested positive for WNV. Based on laboratory vector competence, *Ae. albopictus, Cx. salinarius, Cx. tarsalis, Oc. j. japonicus, Oc. atropalpus* are efficient vectors; *Ae. egypti, Ae. vexans, Cx. nigrapalpus, Cx. pipiens, Cx. quinquefaciatus, Cx. restuans, Oc. triseriatus* are moderate vectors; and *Psorophora ferox, Coquillettidia perturbans, Oc. canadensis, Oc. cantator, Oc. sollicitans, Oc. taenorhynchus* are inefficient vectors (Turell et al. 2003). *Culex* species are the suspected primary vector in the field.

Approximately 80 percent of people who are infected with WNV will not show any symptoms at all. Up to 20 percent of the people who become infected will display mild symptoms, including fever, headache, body aches, nausea, vomiting, and sometimes swollen lymph glands or a skin rash on the chest, stomach and back. Symptoms typically last a few days. About one in 150 people infected with WNV will develop severe illness. The severe symptoms can include high fever, headache, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, vision loss, numbness and paralysis. These symptoms may last several weeks, and neurological effects may be permanent. In a very small number of cases, WNV also has spread through blood transfusions, organ transplants, breastfeeding and even during pregnancy from mother to baby (Anonymous 2003).

St. Louis Encephalitis (SLE) is one of the most common arthropod-borne viruses (arboviruses) in the U.S. In nature, it is maintained and transmitted among birds, primarily by *Culex* mosquitoes. Humans can become ill when bitten by an infected mosquito. Infected individuals may experience abrupt onset of fever, nausea, vomiting, and severe headaches. These symptoms usually develop within 5 to 7 days after someone is bitten. People of any age may contract the disease; however, disease incidence is greater and symptoms more severe in people 60 years or older. Mortality rates range from 2 to 20 percent, with the highest mortality occurring in the oldest age groups.

Humans become infected with SLE only as a result of being bitten by a mosquito that has formerly contracted the pathogen from biting an infected bird. There is no person-to-person transmission via mosquitoes, because the virus concentration (titer) in human blood never reaches a sufficient level to render a biting mosquito infective. Thus, humans are considered to be an "accidental" or "dead end" host for this disease. Disease outbreaks are most likely to occur from mid-summer through early fall when *Culex* populations are at their peak.

Eastern Equine Encephalitis (EEE) is an infection maintained in nature by a bird-mosquito-bird cycle similar to SLE. Horses are involved as dead end hosts in the cycle, as are humans. This virus can infect persons of any age, but young children and infants are most susceptible. Mortality in humans may exceed 50% and can be significantly higher in horses. Children and infants who survive the infection are frequently afflicted with varying degrees of mental retardation and paralysis. *Culiseta melanura* is capable of maintaining and transmitting EEE in nature. Because *Cs. melanura* is uncommon and seldom bites people, other mosquitoes such as *Cx. quinquefasciatus, Ae. vexans* and *Coquillettidia perturbans* may be important in transmission from birds to humans and/or equines. EEE was not reported in Tennesseans from 1964 to 2000.

La Crosse Encephalitis (LAC) The natural cycle of LAC differs from the other encephalitides in that the natural hosts are small animals such as rabbits, squirrels, and chipmunks rather than birds. The primary vector is the eastern tree hole mosquito, *Oc. triseriatus.* Also, the recently introduced Asian tiger mosquito, *Ae. albopictus,* is a vector of LAC. Together they are the most commonly encountered mosquitoes in Tennessee. There were 19 cases reported in Tennessee in 2000, all in children under the age of 16. Symptoms of LAC include fever, headache, nausea, vomiting and lethargy. Severe disease is characterized by seizures, coma, paralysis and other neurological problems and occurs in children under the age of 16. Death from LAC is less than 1 percent of the clinical cases.

Dog Heartworm is caused by the filarial worm *Dirofilaria immitis.* It is a serious disease for all breeds of dogs in

Tennessee. Several mosquito species can transmit this parasite, but *Culex quinquefasciatus* is the most important vector. Mosquitoes ingest the immature worms, called microfilariae, while taking blood from infected dogs. After several days, the fully developed heartworm larvae are transmitted via the mosquito's mouthparts to a healthy dog when the mosquito feeds again. The larvae grow and eventually migrate to the right ventricle of the dog's heart where they mature and reproduce. The adult female worm can grow to approximately 11 inches and the male 6 inches. Large numbers of adult worms can develop in the host dog, and if left untreated will result in death of the infected animal.

Mosquito Surveillance

An effective mosquito management program cannot be planned or implemented until surveys are made to determine which species are present, their relative abundance, and the location of potential larval habitat. Moreover, understanding the biology of the species involved is essential so that control efforts are not only directed at the proper habitat, but at the right time. Surveys can be labor intensive but will allow personnel to focus control efforts on only those species that are causing a problem. This helps mosquito control personnel avoid unnecessary intrusion into areas which do not need to be treated, thus saving time and money.

Surveys for eggs and oviposition sites can often be a useful predictor of mosquito abundance. Mosquito egg surveys for floodwater mosquitoes are often used to schedule an effective pre-hatch application of insecticide. Oviposition traps constructed with a black-painted jar or open can, a wooden paddle serving as the oviposition site, and a little water in the trap, have proven valuable in sampling for *Aedes albopictus* and *Ochlerotatus triseriatus*.

While egg surveys are often useful, larval surveys are the primary means of deciding whether control measures should be applied to aquatic sites. A white dipper equipped with a long handle is the collecting tool most often used (Figure 5-14). Brown larvae can be easily seen on a white utensil. Some "stealth" is required when dipping for mosquito larvae because the larvae quickly swim to deeper water when disturbed. The surveyor must also not overlook obscure larval sites, such as cattle hoofprints in wet pastures or on the edges of water holes and ponds. For examining tree holes, artificial containers, and similarly inaccessible cavities, a large-capacity rubber suction bulb and flexible extension tube can be used to draw out the water into a white metal pan.

An important survey method for collecting adult mosquitoes is the light trap. This mechanical device employs a light to attract flying mosquitoes and a suction fan to draw them into a container. A variety of light traps, such as the New Jersey and CDC, have been designed for sampling mosquitoes. The lightweight CDC trap is the smaller of the two, battery-operated and is portable for use in remote areas. It most be noted that light traps collect only those species attracted to light. Some species are not attracted to light, so are not captured by this technique.

Carbon dioxide (a respiratory gas given off by animals) is a strong attractant to mosquitoes. For this reason, dry ice is often used in conjunction with light traps, resulting in significant increases in the number of mosquitoes caught (Figure 5-15).

Light traps are relatively inexpensive and are easy to set up. They are most useful in determining the presence or absence of a particular mosquito species, and in demonstrating population trends. However, light traps are ineffective for determining the absolute number of mosquitoes in an area. Light traps collect only those mosquitoes that are active at night and are attracted to lights. Therefore, light traps may not necessarily collect all the mosquito species present in the area.

Another disadvantage of light traps is that they are nonselective: they collect all mosquitoes attracted to them as well as flies, beetles, and other insects attracted to light. Many of

Figure 5-14. The most important device is a white enamel dipper equipped with a long handle for sampling larvae and pupae.

Figure 5-15. Mosquito trap with CO2 emission from dry ice.

the mosquitoes caught in a light trap may actually be feeding on reptiles or rodents and may be of little, if any, public health importance. Despite these limitations, light traps are an important surveillance tool.

Another technique used in adult mosquito surveillance is the landing/biting count. This method uses humans or animals as the attractant. The human or animal host is placed at a specific location and remains motionless. Mosquitoes are attracted to the host, and as they land to feed, they are collected with a battery-powered aspirator. This technique is very useful because only those species that bite that particular host will be collected. This technique requires that the host be bitten, and therefore is not recommended when there is a high risk of disease transmission. This technique is not much used any more because of ethical reasons.

Control Techniques

Most successful mosquito management programs concentrate on control of the larvae. This stage of the insect's life cycle is concentrated in specific, identifiable areas. Larval mosquito control can be accomplished either by reducing larval habitats, employing biological control agents, or by applying chemical larvicides (insecticides) to habitats that cannot be eliminated.

Larval Site Reduction. The most effective way to control mosquitoes is to find and eliminate their larval sites. Eliminating large larval areas such as swamps, or sluggishly moving streams or ditches may require community-wide effort. The initial investment is usually high, but significant savings can be realized over time. In these operations, expert advice must be available to prevent potential environmental problems. For example, filling a swampy area may block normal drainage patterns, creating new larval sites or interfering with aquatic life. Before any wetlands are manipulated, contact the Tennessee Department of Environment and Conservation, Division of Water Pollution and the Corps of Engineers to acquire an Aquatic Resource Alteration Permit (ARAP).

In addition to reducing large mosquito larval sites, individual property owners can take the following steps to prevent mosquito breeding on their own premises.

- Dispose of tin and soda cans, old tires, buckets, plastic sheeting, or other containers that can collect and hold water.
- Water should not be allowed to accumulate at the base of flower pots or in pet dishes for more than 5 days.
- Clean debris from rain gutters and remove standing water under or around structures, or on flat roofs.
- Drain children's wading pools when not in use (or at least change the water weekly).
- Change the water in bird baths at least once a week.
- Remove, drain, or fill tree holes and stumps with mortar.
- Eliminate seepage from cisterns, cesspools, and septic tanks.
- Eliminate standing water from around animal watering troughs.
- Irrigate lawns and gardens carefully to prevent water from standing for several days.
- Keep the grass mowed around ponds and other bodies of water, taking care to keep clippings out of the water.
- Maintain farm ponds according to good management practices. Excessive amounts of emergent aquatic vegetation will shelter mosquitoes. Stagnant ponds and waste lagoons also can produce very large numbers of mosquitoes.

Biological Control. Nematodes, planaria, microsporidia, and even other predaceous mosquitoes such as *Toxorhynchites*, show some promise against mosquito larvae. However, the most effective biological control agents to date are predaceous fish such as the mosquito fish, *Gambusia affinis,* and the common guppy, *Poecilia reticulata.* These fish are approximately 1 1/2 inches long and feed voraciously on mosquito larvae. They are commonly found in streams and creeks where they can be seined and transferred to sites harboring mosquito larvae. These fish can be so effective that many county mosquito abatement districts in the U.S. maintain their own fish breeding programs. Drawbacks to using this method are that some mosquito insecticides are lethal to the fish, and other fish species may be displaced.

Chemical Control. The use of insecticides is, at best, a temporary measure that should be limited to only those situations for which no other alternatives exist. Chemical control can be divided into two general categories: (1) Larviciding is the most efficient and effective method and should be the basis of any chemical control program. (2) Adulticiding is less efficient and should be used only for supplemental or emergency purposes. The detection of active transmission of mosquito-borne disease is an example of such an emergency.

Larval Control (Larviciding). Solving a mosquito problem by killing the larvae is the most logical approach because the mosquitoes are being controlled before they become a nuisance. The application of larvicides should only be made at sites where mosquito larvae of the target species are present. The degree of control obtained with larvicide applications depends upon the amount of pollution in the water, as well as the type and amount of vegetative cover present. Where vegetative cover is heavy, granular formulations frequently provide better control than emulsions or oil spays. Repeated insecticide treatments may be needed, especially after heavy rainfall.

Adult Control (Adulticiding). Adult mosquito control programs are most successful if large areas are to be treated. In general, adulticiding provides only temporary relief by reducing populations to less annoying levels. However, this may be the most practical technique for local problems or in the event of a disease outbreak. In addition, some adult mosquito species can fly long distances, often making it necessary to supplement larval control measures with adult control.

• Aerial Application. Application by fixed-wing aircraft or helicopters for control of mosquitoes is a common practice. However, this method is generally not feasible for most areas in Tennessee because of its high costs and potential environmental concerns. In most cases, the insecticides labeled for aerial application are specific formulations designed for this purpose. Aerial applications are most useful under emergency conditions, or when the areas to be treated are too large or inaccessible for treatment with vehicle-mounted equipment.

• Aerosol Application. Aerosols are applied to control mosquitoes outdoors using specialized equipment that dispense insecticides in extremely small droplets. Aerosols work as a contact toxicant and have no residual effect. Consequently, they are effective only as a space treatment against actively flying adults. Aerosols are dispensed from the application device and allowed to drift as a fog with the wind through the target area. This technique is effective only where there is little wind. Aerosols can treat a swath of approximately 300 feet. Because the primary activity period for most pest and vector mosquitoes is during the evening hours and temperature and wind conditions are more ideal, aerosol applications are usually most effective during this period.

•Thermal Foggers. Thermal foggers dispense the insecticide by heating diesel oil or water to the vapor point and releasing the vapors along with the insecticide so that a thick smoke or fog of very fine particles is released. This technique is seldom used any more in the U.S.

•Ultra Low Volume (ULV) Fogging. Special nozzle adaptations and development of micrometering systems now make it possible to apply undiluted insecticides in extremely small droplets (less than 25 um on average) that can give effective coverage for adult mosquito control. Such application techniques now make it possible to reduce application volume to less than 4 fluid ounces of pesticide per acre.

ULV generators have several advantages over thermal fogging units. Less insecticide is applied with ULV, resulting in fewer potential environmental problems. Because smaller quantities of insecticide are applied, smaller holding tanks are needed, allowing smaller, more economical vehicles to be used. Finally, there is a significantly reduced hazard to traffic compared with the near non-visibility created by thermal fog applications.

•Mist Applications. Misting involves applying insecticides suspended in water using powerful mist blowing machines. Mist droplets are somewhat larger than aerosol droplets and settle faster. Thus, misting does not have the "reach" available in ULV applications. However, mists do provide some residual control in addition to contact kill. Avoid direct application to parked cars because their finishes may become spotted if droplets are not washed off immediately.

•Residual (Surface) Spraying. Residual pesticides are usually applied in water using hydraulic field or hand sprayers. This type of application is of limited utility because residual effectiveness of the treatment is usually short. Residual sprays are applied as surface applications to tall grasses, shrubs, trees, buildings, playgrounds, etc.

•Indoor Control. Mosquitoes found inside buildings can be killed with most household aerosol sprays that are labeled for flying insect control indoors. Aerosol space sprays containing synergized pyrethrins often produce rapid results. Doors and windows should be kept closed for 15-30 minutes after spraying. Only products labeled for flying insects should be used.

Repellents. Repellents can protect humans from mosquito bites for 1-12 hrs, depending on how much a person sweats and rubs the skin, and the percentage of active ingredient in the repellent. Repellents are formulated and sold as aerosols, creams, and liquids. Repellents containing ingredients such as diethyl-meta-toluamide (DEET) are most commonly used. The area of skin to be protected should be covered evenly, because mosquitoes will find and bite spots left untreated. It is often helpful to apply repellents on outer clothing as well as the skin because many mosquitoes can bite through thin, tight-fitting clothing. Do not apply repellents to the eyes, nostrils, or lips.

DEET is a very effective repellent but should be used according to the product label. Do not apply DEET to the hands of young children. In addition, in very rare cases, use of this product may cause skin reactions. If a reaction to DEET is suspected, wash the affected area and contact the local poison control center. See the CDC Web site (http://www.cdc.gov/ncidod/dvbid/westnile/qa/insect-repellent.htm) for guidelines for applying repellents.

Additional Control Measures

Vegetation Management. Many adult mosquitoes prefer to rest on weeds and other vegetation. Trimming or eliminating areas of dense vegetation will force mosquitoes to find other, more distant, resting sites.

Mechanical Barriers. Mosquitoes can be kept out of buildings by keeping windows, doors, and porches tightly screened with 12-18 mesh screening. This method is not as important in buildings that have air conditioning. Those few insects that do get into structures can be eliminated with a fly swatter.

Insect Electrocutors. Insect electrocutors (e.g., "bug zappers"), using ultraviolet light as an attractant, are generally ineffective at reducing outdoor populations of mosquitoes or their biting activity. Light traps using ultraviolet light do capture large numbers of flying insects, including mosquitoes, when used inside buildings.

Numerous other devices are available that claim to attract, repel, or kill outdoor infestations of mosquitoes. Individuals considering purchasing such devices should first consult with a mosquito specialist.

Public Education

All good public health programs must include community-wide education of the public to gain and maintain support. This is especially important with mosquitoes. Widespread aerial spraying for mosquitoes can produce anxiety and concern over the effects of pesticides on human health. Homeowners can be of great help by managing their own property to eliminate larval habitat of several mosquito species. The effectiveness of any area-wide public health program can only be helped if people understand the program's benefits and limitations.

Itches, Irritation and Delusions

There are many possible causes of itches and irritations other than pests. Allergies, cosmetics, medications and environmental contaminants (coarse fibers or paper shards in a dry environment charged with static electricity) all can result in reactions similar to insect bites. Table 5-2 can be used as a checklist to aid clients in determining the cause of an itch.

If the client still insists that insects or mites are biting, pat strips of cellophane tape over the affected area and gently place on a white index card. Glue boards can be placed in

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 paints and adhesives	diabetes
ticks	printing inks	seasonal changes in temperature	tobacco smoke	liver or kidney disorders
bedbugs	clothing	static electricity	volitiles for asphalt and tar installation	food allergies
				insect phobias

Table 5-2. 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.

the environment to trap biting organisms, as well as, fibers and paper shards.

Delusory parasitosis is a more serious emotional disorder characterized by an irrational fear that living organisms are infesting a person's body. These cases often have similar symptoms and patterns of behavior. Patients typically report "insects" invading their ears, nose, eyes and other areas of their body. These "creatures" frequently disappear and reappear, but can't be caught 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 and sometimes infected 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.

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. _____ are found living indoors more often than other ticks.
   A. American dog ticks
   B. Lone star ticks
   C. Brown dog ticks
   D. Relapsing fever ticks

3. In Tennessee, cat fleas are a medical concern because they transmit _____.
   A. dog tapeworm
   B. Rocky Mountain spotted fever
   C. Lyme Disease
   D. LaCrosse 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. Lyme disease is transmitted by _____, which is rarely found in Tennessee.
   A. *Dermacentor variabilis*
   B. *Amblyomma americanum*
   C. *Rhipicephalus sanguineus*
   D. *Ixodes scapularis*

6. 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

7. The preferred host of the common bed bug is _____.
   A. humans
   B. bats
   C. bugs
   D. birds

8. 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

9. 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

10. The use of insecticides for mosquito control is, at best, a temporary measure that should be limited to only those situations for which no other alternatives exist.
   A. True
   B. False

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

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 and clothes moths are discussed here.

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. 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* (Fabr.); varied carpet beetle, *Anthrenus verbasci* (L.); common carpet beetle, *Anthrenus scrophulariae* (L.); and furniture carpet beetle, *Anthrenus flavipes* LeConte. Two species are discussed here.

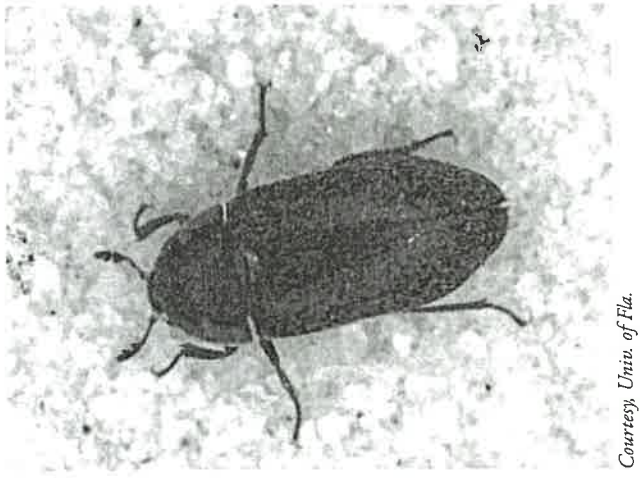
Identification

Adult black carpet beetles (Figure 6-1) are oval and shiny black with brownish legs. They vary in body 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 (Figure 6-3). The top body surface is usually gray with a mixture of white, brown and yellow scales and irregular black crossbands. The bottom surface has long, gray-yellow scales. Larvae are about 1/4 inch long and are light to dark brown. The body is wide and broader at the rear than the front (Figure 6-4).

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 of spirea, crepe myrtle and buckwheat. Depending on the species, each female can lay up to 100 or more white eggs, which hatch 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, avoid light and molt several times as they develop. Depending on food and temperature, the larvae may spend sixty 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.

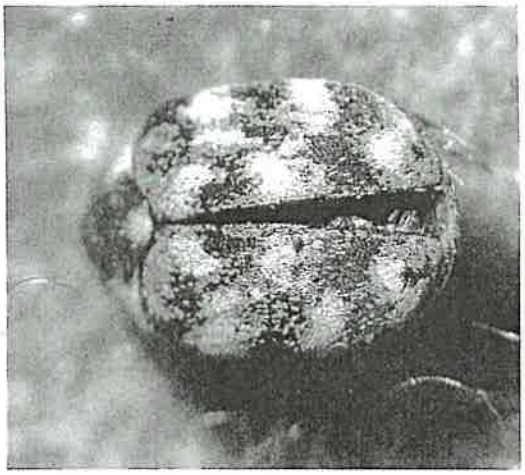


Courtesy, Univ. of Fla.

Figure 6-1. Black carpet adult.

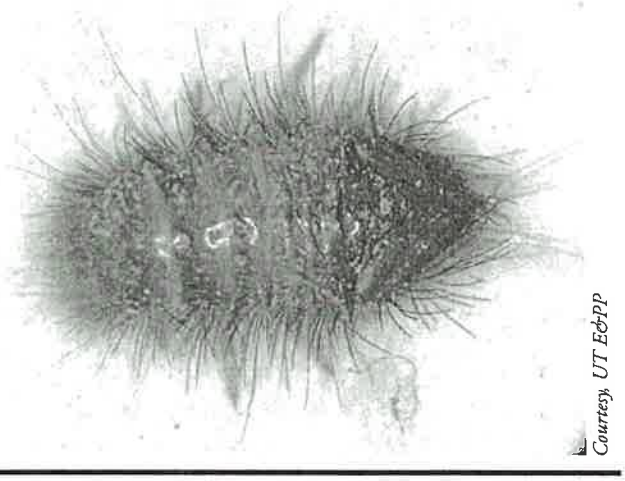
Courtesy, UT Ext-PP

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.

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* (Hummel), casemaking clothes moth, *Tinea pellionella* Linnaeus and carpet or tapestry moth, *Trichophaga tapetzella* (Linnaeus).

Identification

Adult webbing clothes moths (Figure 6-5) have a wingspread of about ½ 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 ½ inch long, spin long threads and construct tunnels of silk.

Adult casemaking clothes moths have a ½ 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 6-6).

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 (especially webbing clothes moths) travel by either running or hopping. 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 of 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.

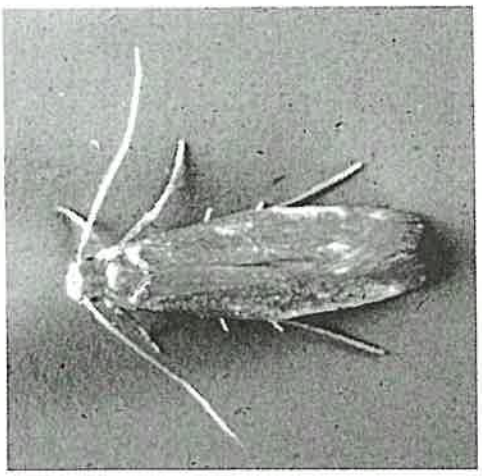
Control of Fabric Pests

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, carpets, clothes closets, furs, etc. Cast skins, which are shed during molting, may be more abundant than larvae. Adult carpet 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 into the house. Adult moths do not feed in fabrics, but may be seen in darkened corners at night.

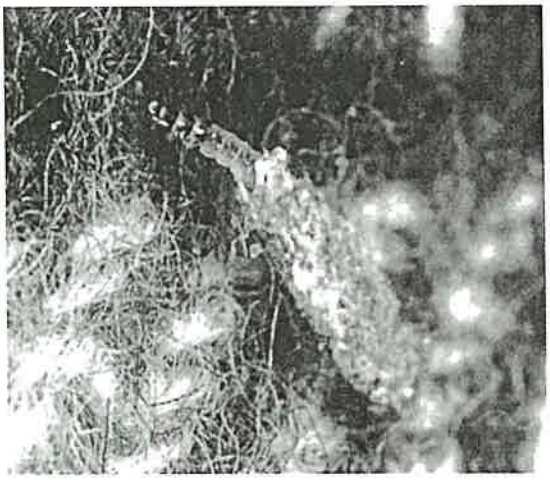
Prevention

Good housekeeping is critical in preventing or controlling clothes moth and carpet beetle damage and the following



Courtesy, Univ. of Fla.

Figure 6-5. Webbing clothes moths are buff colored and hairs on head are upright and reddish gold.



Courtesy, Clemson Univ.

Figure 6-6. The larva of the casemaking clothes moth spins small silken case around itself.

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, draperies, furniture, carpets, molding and other hard-to-reach places. Periodically brush, air outside or dry-clean furs, woolens, blankets, etc. Destroy untreated, worthless animal skins, valueless insect collections, old woolen rags and old clothing. 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. 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 under these 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.

Antique upholstered furniture and pillows stuffed with horse hairs or similar material, may require fumigation by a pest control operator as surface sprays would not be effective. Fumigation requires certification in category 7 and supervision by a person licensed to fumigate (FUM). 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.

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. Varied 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

7. 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

8. Clothes moths are attracted to lights and therefore are often confused with Indianmeal moths.
   A. True
   B. False

9. _____ moths are the most commonly encountered clothes moth in Tennessee.
   A. Common clothes
   B. Webbing clothes
   C. Carpet or tapestry
   D. Casemaking clothes

10. _____ moths are 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. A, 7. D, 8. B, 9. B, 10. 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.

To control losses from stored product pests, (1) use management methods that prevent pest infestation, (2) control 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.

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 can be found in Table 7-1, 7-2 . Although the black carpet beetle is a fabric pest, which is described in the previous chapter, it is also a widespread stored products pest that feeds on a large variety of dried foods including beans, peas, corn, wheat, rice and many types of seeds.

Moth larvae 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.

Management Guidelines for Stored Product Insects

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 (or returning them to the grocery store for a refund) and storing uncontaminated food products in insect-proof containers.

Similar infestations occurring in grocery stores, warehouses, or packaging and processing plants can result in considerable loss of investment and revenue. 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. Use pheromone traps inside a building or structure to monitor pest activity; pheromones are available for most of the insects that damage stored food. Check traps regularly and record the number of pest insects caught and remove them from the traps. Replace pheromones and traps as suggested by the manufacturer or when the boards are no longer sticky. Pheromones or attractants can sometimes be used in traps to aid control of stored product insects. Trapping may be a preferable control

method over insecticides because foods are not exposed to their residues.

Exclusion. Prevent insect entry into the storage facility by inspecting grains, cereals, flour and other bulk and packaged products as they arrive. Keep insects out of buildings by using screens over doors and windows. Close off all other openings with wire screening or caulking. Locate and close rodent holes as stored product insects can enter through these. To keep from attracting insects into buildings, locate outdoor lighting away from doorways and use sodium-vapor lights rather than mercury-vapor lights for outdoor lighting.

Sanitation. 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. Clean conveyors, augers and food processing machinery.

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 insecticides, such as insect growth regulators and *Bacillus thuringiensis,* when insects are most susceptible.

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 its concentration can build up to high enough levels; other conditions must also be met and specific problems overcome before fumigation. Professionals need to be licensed in fumigation (or under the direct supervision of a operator licensed in fumigation) before applying fumigants.

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.

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.

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 over 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 stored product mites 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. Check for moldy areas and for mites associated with fungus. 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 fungal growth. Psocids and mites need a high humidity to build large populations. Keeping the stored product at or below a moisture content of 12% 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

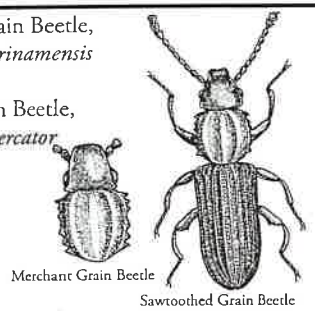
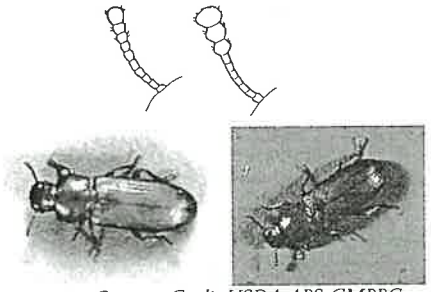
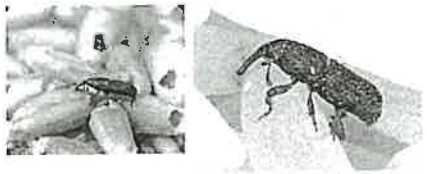
Pest	Identification Characteristics	Behavior/Life cycle	Food
Sawtoothed Grain Beetle, *Oryzaephilus surinamensis* Merchant Grain Beetle, *Oryzaephilus mercator*  Merchant Grain Beetle Sawtoothed Grain Beetle	**Size:** Adults about 1/10 inch **Color:** Reddish brown to dark brown **Adult Characters:** Lateral margins of the thorax contain sawtoothed projections on sides. Long, narrow beetles with flattened bodies. The area behind the eye is smaller and more pointed in the merchant grain beetle as compared to the sawtooth grain beetle. **Larval Characters:** Larvae have brown heads and their bodies are yellowish, elongated and segmented, with three pairs of legs. They crawl actively during feeding.	Adults of both species are usually seen running rapidly over stored food. Adult females lay between 45 and 285 eggs singly or in small batches in or around suitable larval food sources. Eggs hatch in about eight days. Larvae pass through two to four instars over an average of 37 days and pupation takes another six days. Temperature and humidity affect the development time and the number of larval instars.	Sawtoothed grain beetle larvae feed on items such as rice, wheat and nutmeats. These insects probably cannot attack whole, undamaged grains, so may be associated with other whole-grain pests and feed on the kernels damaged by these other pests. The merchant grain beetle is not a major pest of grains or cereals, but prefers seeds and nuts.
Confused Flour Beetle *Tribolium confusum* Red Flour Beetle *Tribolium castaneum*  *Courtesy, Credit USDA-ARS-GMPRC*	**Adult Size:** About 3/16 of an inch **Adult Shape and Color:** Flattened and shiny reddish brown **Adult Characters:** 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. **Larval Characters:** Larvae are slender and wirelike, whitish colored with yellow tinges. They are distinguished from other stored product insect larvae by the prominent, two-pointed termination of the last body segment.	Adult flour beetles live up to two years. Adult beetles run quickly when disturbed. Females produce 400 to 500 eggs in their lifetime, laying two or three per day; eggs hatch in five to twelve days. Larvae pass through five to 18 instars, typically seven or eight, over a period ranging from one to four months.	They feed on damaged grains, flour, cereals and other stored products. In addition to feeding damage, they produce secretions that contaminate the material they feed on, giving it a disagreeable odor and taste. The confused flour beetle and the red flour beetle are the most common and serious pests of flour, cereal and broken grains.
Granary Weevil *Sitophilus granarius* Rice Weevil *Sitophilus oryzae*  *Courtesy, Univ. of Fla.*	Snout or slender elongation of their heads. **Granary weevil:** About 1/8 inch long, shiny dark brown or black; top central area of its thorax is covered with elongated depressions or punctures; adults do not fly. **Rice weevil:** Slightly smaller; reddish brown to black; top-central area of the thorax covered with round punctures; four reddish or yellowish spots on its elytra; a good flyer.	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.	Both 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 never forage in the wild for food. Rice weevils 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. Both are serious grain pests.

Table 7-1. Identification characteristics of common stored product beetles.

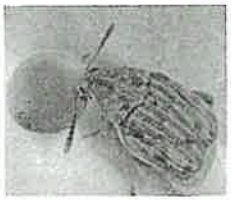
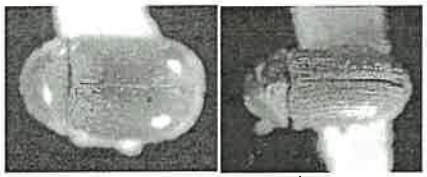
Pest	Identification Characteristics	Behavior/Life cycle	Food
Bean Weevil *Acanthoscelides obtectus*  *Courtesy, Kansas State Univ.*	**Adult Size:** About 1/2 inch long **Adult Shape and Color:** Light olive brown with darker brown and gray markings and reddish legs. **Adult Characters:** Not weevils but belong to the seed beetle family Bruchidae.	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. Larvae bore into seeds where they reed and pupate. After pupation, adults bore an emergence hole in the seed. Often more than one larva infest a single seed. Adults hibernate during the winter, but if temperatures rise, they emerge and females begin egg laying again.	Eggs are laid on pods of larvae 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.
Cigarette Beetle *Lasioderma serricorne* Drugstore Beetle *Stegobium paniceum*  *Courtesy, UT E&PP*	**Adult Size:** About 1/8 inch long Adult shape and Color: Reddish yellow to brownish red **Adult Characters:** In powderpost beetle family called Anobiidae. Head is below prothorax and cannot be seen when viewed from above. **Cigarette beetle:** saw-like antennae; shiny elytra; distinct humped appearance **Drugstore beetle:** antennae have a 3-segmented club; elytra with longitudinal striations, or ridges; appearance less humped	**Cigarette beetle:** Females produce about 30 eggs over a three-week period; these usually hatch within one week. Larvae are curved, plump and hairy; they are yellowish with a light brown head. The larval stage lasts from five to ten weeks and three to six broods are produced in a year. **Drugstore beetle:** Drugstore beetles usually have one to four generations per year. They complete a life cycle in about two months. They can survive on items with low food value because of yeast-like organisms in their digestive systems that produce some essential vitamins.	**Cigarette beetle:** Stored food such as tobacco, rice, raisins, grains, pepper and many other stored products. **Drugstore beetle:** Every type of stored product as well as spices, drugs, books and wood.

Table 7-1. Continued

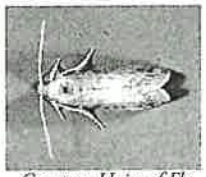
Pest	Identification Characteristics	Behavior/Life cycle	Food
Indianmeal Moth *Plodia interpunctella*  *Courtesy, Univ. of Fla.*	**Adult Size:** Wingspan of about 3/4 inch **Adult Color:** Pale gray with the outer two-thirds of the forewing with reddish-copper scales. **Larval Characters:** Larvae are a dirty-white color but may take on different hues depending on the food ingested. The larva's head and prothoracic shield are brown.	Egg laying usually begins in April Females lay eggs at night, either in masses or singly and produce 200 to 400 eggs. Pupation takes place in a silken cocoon. The larval period varies greatly between one and ten months, depending on environmental conditions and available food. The normal complete life cycle of this pest takes about six to eight weeks.	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. The most common pest of coarsely ground flours (such as whole wheat flour) and cornmeal. It is widespread in grocery stores, warehouses and kitchens. Unlike weevils and other beetle larvae, Indianmeal moths spin large amounts of webbing, further contaminating food products.
Almond Moth *Cadra castellan*  *Courtesy, Univ. of Fla.*	**Adult Size:** Wingspan of about 1/2 to 3/4 inch **Adult Color:** Mottled gray color and may have a fawn-colored pattern on the forewing. **Larval Characters:** Larvae are dirty-white tinged with brown or purple dots, giving them a striped appearance.	Females lay an average of 100 eggs, which hatch in about a week. The larval period usually continues for two months.	Cereals, dried fruits, flour, grain, seeds and shelled nuts. Lesser importance than the Indianmeal moth. They leave matted webbing as they feed.

Table 7-2. Common stored product moths.

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. Pheromones are used in _____.
   - A. sprays
   - B. traps
   - C. dusts
   - D. warehouse foggers

3. Pest-free items should be stored near infested items to keep the infestation from spreading.
   - A. True
   - B. False

4. Psocids and grain mites need _____ to build large populations.
   - A. grains
   - B. processed meal
   - C. high protein
   - D. high humidity

5. Merchant grain beetles' area behind the eye 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

6. 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

7. Granary weevils never forage in the wild for food.
   - A. True
   - B. False

8. Which is not an example of an anobiid beetle?
   - A. Cigarette beetle
   - B. Drugstore beetle
   - C. Powderpost beetle
   - D. Red flour beetle

9. The most common pest of coarsely ground flours and cornmeal is a(n) _____.
   - A. black carpet beetle
   - B. Indianmeal moth
   - C. cigarette beetle
   - D. drugstore beetle

10. Keeping the stored product at or below a moisture content of 30 percent retards development of many mite species.
   - A. True
   - B. False

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

Management for pests, such as millipedes, springtails, pillbugs or roly-polies, that need a high moisture environment and are often found around the perimeter of the structure can be managed in a similar manner. 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 good landscaping practices will help eliminate pest-infested sites near structures. Also, pest exclusion, caulking or otherwise sealing cracks and pipe penetrations and other openings in the foundation, adding weatherstripping around doors and windows, screening of vents, and changing lighting location or type (sodium vapor lights are less attractive to pests) can solve many problems with occasional invaders. See Chapter 2 for more details regarding pest proofing.

One study reduced millipede invasions into a structure by 93% 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 it to dry more quickly,
- debris and mulch were pulled away from the structure (at least 18 inches) to reduce hiding places, and
- grass was watered early in the morning to allow it to dry later in the day.

In addition, compost piles and decaying vegetation should be moved away from areas close to the home because they provide food and habitat and attract pests with the odors they produce. Shrubs should be trimmed to prevent them from touching the structure and to allow good air flow to reduce molds and mildews. Water should drain away from the base of the structure. Low moisture should be present in crawl spaces. A 12- to 18-inch bare zone should remain next to the base of the structure. Mulches, river stone and other rocks next to the foundation could retain moisture thus making the area more conducive to many occasional invaders.

While sealing is the more permanent way to exclude pests originating from outdoors, comprehensive pest-proofing is labor-intensive and sometimes impractical. For clients requiring an alternative, pest proofing can be supplemented by an exterior treatment with an insecticide. Treatment may be needed at the base of all exterior doors, garage and crawl space entrances, around foundation vents and utility openings, and up underneath siding. It may also be useful to treat around the outside perimeter of the foundation in a 2 to 6- foot-wide band along the ground, and 2-3 feet up the foundation wall. Many pest management professionals do not spray this wide a perimeter band because of client pressure to reduce pesticide exposure. Treatments to all areas mentioned above may not be allowed for all pesticides. As directed earlier, read the label prior to using a pesticide.

See Table 8-1 for the common occasional invaders, their identification, behavior and management.

Pest	Identification Characteristics	Damage/Behavior/Life cycle	Management
Foreign grain beetle *Ahasverus advena*  *Courtesy, UT E&PP*	**Size:** small, 1/2 inch **Color:** adult reddish-brown **Adult Characters:** projecting rounded lobe on the front corners of the pronotum	From mid-July through September, the adult 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.	Eliminate wet wood and the moisture source. Add ventilation such as air conditioners or fans. Homes will dry out naturally in 1 – 4 years. Vacuum or use pyrethrin sprays with vacuuming to kill and remove the adults. A residual aerosol or dust can then be injected into cracks and crevices along baseboards and into the wall voids. Beetles may still emerge from the baseboards and die on the floor.
House cricket *Acheta domesticus*  *Courtesy, Univ. of Florida* Camel cricket *Ceuthophilus* spp.  *Courtesy, Clemson Univ.*	**House Cricket** **Size:** ½ and ¾ inch. **Color:** light yellowish brown, with three dark bands on the head, or solid shiny black. **Camel Cricket** **Size:** may be greater than one inch, humpbacked, very large hind legs and long antennae. **Color:** brownish, wingless **Behavior:** high jumping ability, upside down resting state, no sound produced, grey feces may pile on the ground below them.	Crickets damage fabrics or other materials. Occasionally invade a structure in large numbers. Attracted to lights around a building at night. Besides damage, house crickets' chirp may become annoying to building inhabitants. Nuisance in buildings, but have eaten holes in lace curtains and clothes hung to dry. Active at night and are attracted to cool, damp situations found in sheds, under concrete pads or air-conditioning units, in wells, basements, crawl spaces, utility rooms and garages and other areas where moisture accumulates. Hot and dry weather may cause the crickets to move indoors in search of moisture.	**Exclusion:** Sanitation and exclusion are very important in the control process. Install vents with screens and vapor barriers and/or French drains in the crawl space. Reduce or eliminate moist harborage around the structure. Remove weeds and piles of wood, bricks, leaves and other debris. Seal cracks and gaps in foundations, siding, or around windows and doors. Place glue boards near entry points to trap and detect crickets. Vacuums are also effective in removing this pest. Remove dead crickets to prevent the build up of carpet beetles and odors. Use insecticides if sanitation and exclusion results are not quick enough. Apply baits indoors to cracks and crevices, wall voids, unfinished attics and crawl spaces within buildings. Spray entry points. Dusts can be blown into inaccessible places.
Silverfish, fire brats and bristletails  *Courtesy, Univ. of Florida*	**Size:** 1/3 to ¾ inch long **Color:** silver, or light to dark gray, sometimes mottled gray. **Adult Characters:** wider at the front end than the rear. Wingless insects covered with scales; two long, slender antennae and three long, tail-like appendages on the rear. The firebrat's antennae exceed the end of the abdomen. Young resemble the adults.	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. They are active at night and often found trapped in a bathtub, sink or wash basin. Silverfish live and develop in dark cool places and firebrats live in hot, dark places (near furnaces, fireplaces, or insulation around hot pipes). They can live without food for many months.	Sanitation is important but not entirely effective in reducing populations. Remove old stacks of newspapers, magazines, paper, books and fabrics stored for long periods of time, as well as spilled food. Reducing available water and lowering relative humidity with dehumidifiers and fans may help. Lighting a dark sheltered area may force these insects to move to new sites where they can be controlled more easily. Inspect food, furniture, old books, papers and clothing when brought into the structure. Insecticide formulations such as dust, baits or sprays should be applied thoroughly 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 wall to treat large populations.

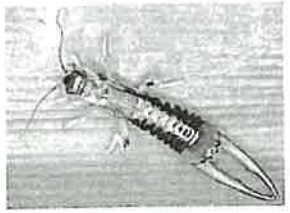
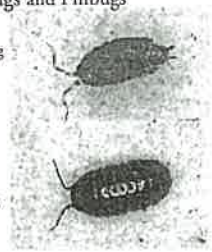
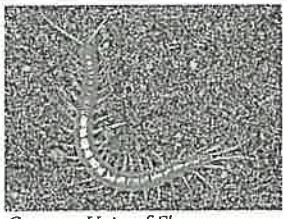
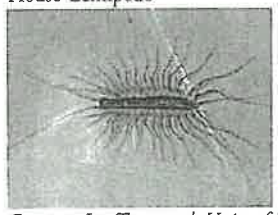
Pest	Identification Characteristics	Damage/Behavior/Life cycle	Management
Psocids or booklice  *Courtesy, Univ. of Fla.*	**Size:** most are less than 1/8 inch long. **Color:** colorless, gray to light brown **Adult Characters:** small soft-bodied insects; most indoor species are wingless. Psocids have chewing mouthparts.	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.	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. Non-residual space sprays may cause booklice to disperse through buildings.
Springtails  *Courtesy, UT E&PP*	**Size:** extremely small, 0.04 to 0.08 inch (1 - 2 mm) **Color:** white or gray **Adult Characters:** 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 these insects got their name.	Common outside soil insects that become problems in homes and other structures when they invade in enormous numbers. 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. 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 wet areas quickly.	Springtails often breed in moist conditions outdoors and may enter homes or other structures under doors when attracted to light and moisture. They are particular problem in newly built buildings with wet materials. Dry outdoor environment, seal entry points and apply pesticides to entry points.
Earwigs  *Courtesy, Univ. of Fla.*	**Size:** 1/2 to 1 inch long **Color:** usually dark brown **Adult Characters:** a pair of pincerlike appendages at the tip of the abdomen; beetle-like, short-winged, fast-moving insects. The name earwig is derived from an old superstition that these insects enter peoples' ears.	Earwig; 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. They are often outside unless populations are large or other conditions are adverse. 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.	Vacuum earwigs in home. Eliminate damp, moist conditions in crawl spaces under houses, around faucets, around air-conditioning units and along house foundations. Earwig; are difficult to control with chemicals. Apply barrier treatment of residual insecticides late in the afternoon or early evening because earwig; are active at night.

Table 8-1. Identification and control of occasional invaders.

Pest	Identification Characteristics	Damage/Behavior/Life cycle	Management
Sowbugs and Pillbugs  *Courtesy, Univ. of Fla.*	**Size:** about ½ inch in length **Color:** slate-gray **Adult Characters:** common crustaceans that are wingless, oval or slightly elongated with body segments appearing as armored plates. **Sowbugs:** have two taillike appendages; pillbugs or roly-polies don't, but can roll into a tight ball	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. Mulches, grass clippings and leaf litter often provide the decaying organic matter these bugs need to survive.	Sowbugs and pillbugs cause no damage inside the home. Mechanical control may be adequate indoors. Seal entry points into structure. Remove piles of leaves, grass clippings, fallen fruit, boxes or boards and other debris from near the structure. If necessary, treat outdoors near foundations 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  *Courtesy, Univ. of Fla.* House Centipede  *Courtesy, Lee Townsend, Univ. of Ky.*	**Size:** vary in length from 1 to 6 inches **Color:** brownish **Adult Characters:** flattened animals with many body segments; most body segments have one pair of legs; are fast runners and have one pair of antennae that are easily seen **House centipedes:** body with very long, thread-like legs with dark and light bands, body with 3 dark stripes.	Centipedes and millipedes are commonly seen in yards and occasionally enter homes. Neither centipedes nor millipedes damage furnishings, home or food. 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. Centipedes are usually associated with damp, dark places such as under stones, leaf litter, logs, bark or soil crevices. Indoors they may be round in closets and bathrooms where there is high humidity.	Caulking can also be performed along with other exclusion practices to prevent entry into the structure. Control insects on which they reed. Remove centipedes with a vacuum. Spot treatments of residual insecticides to infested areas aids in control .
Millipedes or "thousand leg"  *Courtesy, UT Ec&PP*	**Size:** about 1 inch to several inches **Adult Characters:** 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.	Millipedes as with other pests with high moisture requirements should die after several days indoors. Caulking can also be performed along with other exclusion practices to prevent entry into the structure. Reduce moisture levels in lawn and areas surrounding the structure. Dethatch the lawn and closely mow the lawn. Remove mulch and decaying matter from near the foundation Water plants in morning so soil dries between watering. 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. Remove individuals with a vacuum.

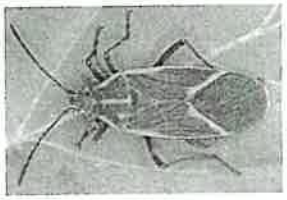
Pest	Identification Characteristics	Damage/Behavior/Life cycle	Management
Multicolored Asian Lady Beetle *Harmonica axyridis*  *Courtesy, Univ. of Kentucky*	**Size:** ¼ inch long **Adult Characters:** orange-red beetles with 0 to 19 square-shaped dots on elytra, black spots that form an "m" or "w" on the pronotum.	Beneficial insect that feeds on aphids. In the fall, invade homes in search of a protected over-wintering site.	By September, perform the following exclusion practices to seal gaps > 1/8 inch. Caulk around window frames; fit doors, including garage doors, with sweeps if needed; use foam weather stripping in the tracks below sliding glass doors; seal openings, foundation penetrations such as outdoor faucets, gas meters, dryer vents, wires, pipes; and screen attic and crawl space vents. Pyrethroids can be applied to potential outdoor entry points before beetles arrive. Once beetles invade, use a vacuum or glue boards to remove from the interior. Indoor traps have had variable results often due to competition with natural light sources.
Scorpion  *Courtesy, Texas A&M*	**Adult Characters:** flattened, crab-like animals having 10 legs and a fleshy tail, ending in an enlarged, upturned tip that bears a stinger.	Scorpions are most active at night and feed on insects, spiders and similar small animal life. Scorpions will sting, but usually when provoked or disturbed. Tennessee scorpions' neurotoxins are usually insufficient to prove fatal to an adult; however, the sight of the sting may be sore and swollen for some time.	Pest proof to deny pest access to the structure. Remove outdoor harborage sites including stacks of wood, brick, block, etc. Scorpions also shelter under railroad ties, rocks, mulch and more. Scorpions will fluoresce under a black light, so they and their breeding areas can be seen at night. Mechanically destroy scorpions as they are found. Treat hiding and breeding areas with residual sprays or dusts. Use glue boards to trap scorpions and locate infested areas.
Boxelder bug *Leptocoris trivittatus*  Red-shouldered bug *Jadera haematoloma* 	**Boxelder:** Adults are flat, about l/2 inch long, 1/3 inch wide and dark brownish-black with three lengthwise red stripes on the pronotum. There are red veins in the wings; the abdomen is bright red under the wings. Nymphs are smaller, wingless and bright red. **Red-shouldered bug:** Similar to boxelder bugs, except red-shouldered bugs lack the central red stripe on the pronoturn and the red stripes on the wings.	Adult and large nymph boxelder bugs congregate in large numbers, primarily on the bark of boxelder trees, and then begin migrating to a place for over wintering. Only adults overwinter and seek cracks and crevices in walls, in door and window casings, around foundations, in stone piles, in tree holes and in other protected places. On warm days during winter and early spring, they may appear on light painted surfaces outdoors on the south and west sides of the house, resting in the sun. Boxelder bugs feed primarily on the seed-bearing boxelder trees by sucking sap from the leaves, tender twigs and developing seeds. Occasionally, they have been observed feeding on other plants (see SP341 H for a complete list); however, boxelder bugs seldom develop in large enough numbers to become a nuisance unless able to feed on pod- bearing boxelder trees. In Tennessee, red- shouldered bugs have been found feeding on seeds of goldenrain tree, but also may suck juices from fruits of other trees (see SP341H for a complete list).	**Outdoors - Host removal.** Because boxelder bugs breed only on female boxelder trees, removal of these trees may reduce nuisance populations. **Outdoors - Exclusion and Sanitation.** Be sure to repair and close openings where boxelder bugs can enter the house before bugs start moving off their host in the fall **Outdoors - Removing Bugs by Vacuuming.** A wet/dry vacuum cleaner with a soapy water mixture (one teaspoon of a liquid household detergent per gallon of water) can be used to remove bugs. The bugs will drown quickly in the soapy water. **Outdoors - Insecticides on Trees.** Inspect boxelder and other host plants during spring and early summer for young, exposed boxelder bugs and treat to prevent potentially large populations and indoor migrations in the autumn. **Outdoors - Insecticides on Structures and Other Objects.** As boxelder bugs mature and leave the trees, massing on foundation walls, sidewalks, fence rows, etc., they may be killed with sprays. **Indoors.** Use a vacuum cleaner to remove bugs indoors.

Table 8-1. Continued.

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. Sowbugs and pillbugs usually feed on _____.
   - A. live insects
   - B. decaying organic matter
   - C. old medicine pills
   - D. fresh flowers

6. Centipedes and millipedes typically damage _____ in homes.
   - A. furnishings
   - B. food
   - C. walls
   - D. nothing

7. Centipedes feed on _____.
   - A. live insects
   - B. decaying organic matter
   - C. old medicine pills
   - D. fresh flowers

8. Millipedes feed on _____.
   - A. live insects
   - B. decaying organic matter
   - C. old medicine pills
   - D. fresh flowers

9. Which do not coil or roll up when disturbed?
   - A. Pillbug
   - B. Centipede
   - C. Millipede
   - D. All of the Above

10. One study reduced millipede invasion by into a structure by _____% 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. A, 8. B, 9. B, 10. A

Chapter 9 Vertebrate Pests

Wildlife damage management 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, relocation 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-tail deer); however, when serious damage is occurring shooting permits may be obtained from TWRA.

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.

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 diseases, most notably 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 and hantavirus.

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).

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 2 to 3 months. Females have 4 to 6 litters each year with 6 to 12 young per litter.

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 along

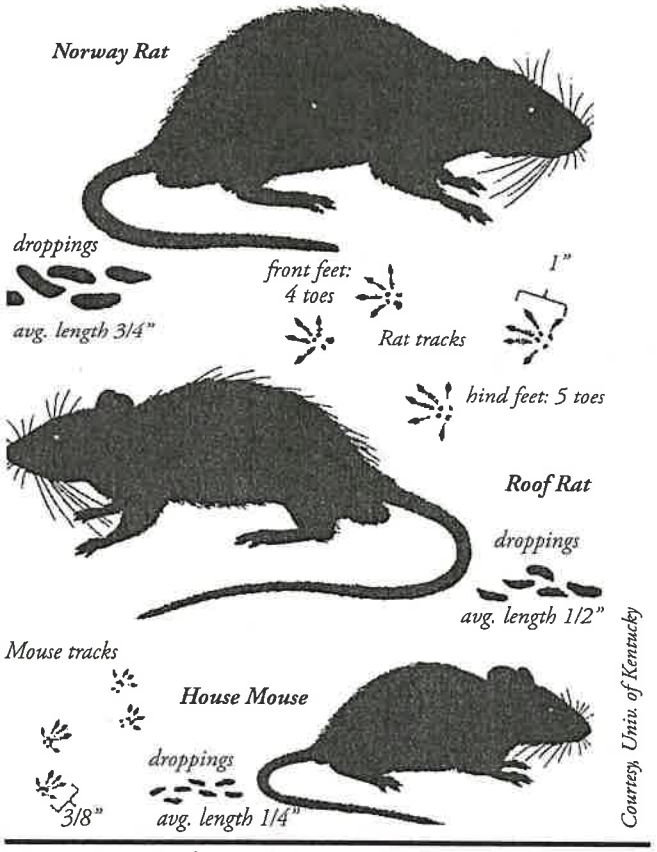


Figure 9-1. Rodent adults, tracks and feces.

the ground. Indoors, Norway rats prefer to nest in the lower portions of buildings in wall voids, underneath floors, in crawl spaces 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 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).

Figure 9-2. Norway rat.

Figure 9-3. Roof rat.

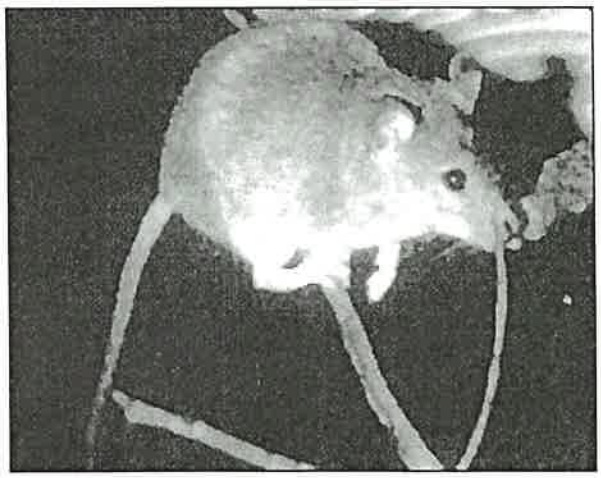
House Mouse. The house mouse (Figure 9-4) is the smallest domestic rodent. Adults are 2 1/2- to 3 1/2-inches long, with a 3- to 4-inch semi-hairless tail. House mice are gray to brown and have large ears. Mouse droppings are 1/8- to 1/4-inch long with at least one of the ends pointed.

House mice only live about a year, but are prolific breeders. Females produce 6 to 10 litters continuously throughout the year with 4 to 7 young per litter. House mice may live indoors or outdoors. Outdoors, they often live among weeds and shrubbery or near building foundations, inside 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.

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:



Courtesy, NPRWC

Figure 9-4. House mouse.

1) Droppings are the most common indicators of rodent presence and provide valuable clues where to place control devices.
2) Runways/Rub Marks.
3) Burrows (Figure 9-5).
4) Tracks.
5) Gnawing Marks.
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.
9) Nest and food caches.
10) Pet excitement.

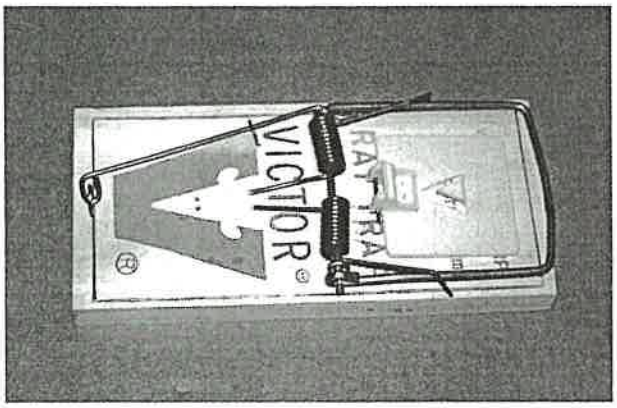
Sanitation. Rodents must have food, water and shelter to survive. Limiting availability of these essential resources will help to reduce rodent problems. Garbage, pet food and bird seed should be kept in rodent-proof containers. Weeds and unnecessary vegetation should be removed, especially when they are adjacent to building foundations. Rubbish, lumber, rock piles and old equipment should be eliminated, as should standing water. Boxes, crates and other items should be stored at least 18 inches off the ground and 12 inches away from walls.

Rodent-Proofing. Along with proper sanitation, the best way to avoid rodent problems in buildings is to prevent their entry. 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 the size of a quarter (1/2-inch). Cracks and openings under doors, around windows, 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

Courtesy, UT E&PP

Figure 9-5. Norway rats prefer to nest in



Courtesy, UT E&PP

Figure 9-6. Snap trap with expanded trigger.

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. Another very effective trap against mice is the automatic, multiple-catch trap (Figure 9-8). Glue boards are also very effective against rodents, especially mice.

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. 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. See Chapter 3 for a discussion of rodenticides.

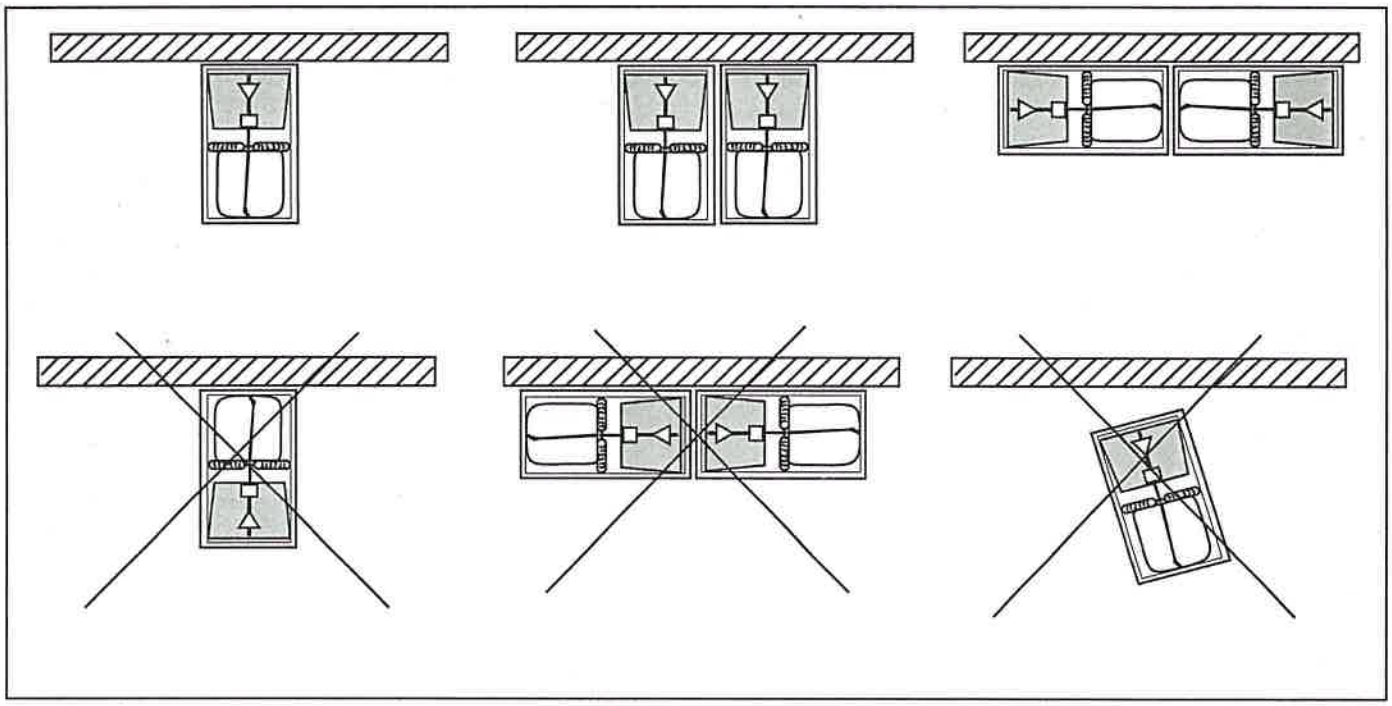


Figure 9-7. Snap traps should be oriented perpendicular to the wall, with the trigger against the vertical surface.

Birds

Health risks from birds are often exaggerated. Nevertheless, large populations of roosting birds may present risks of disease to people nearby. Food may be contaminated by birds, but this risk is usually limited to food manufacturing or processing plants. When parasite-infested birds leave roosts or nests to invade buildings, their parasites can bite, irritate, or infest people. Serious health risks arise from disease organisms growing in accumulations of bird droppings, feathers and debris under a roost. If conditions are right, particularly if roosts have been active for years, disease organisms can grow in these rich nutrients.

Histoplasmosis, a systemic fungal (mold) disease is transmitted to humans by airborne spores from soil contaminated by pigeon and starling droppings (and those of other birds and bats) for three years or more during which the disease organism (*Histoplasma capsulatum*) increases to significant levels. Although usually associated with soil, in rare instances the fungus has been found in droppings alone, such as in attics. Birds are also involved in transmission of other diseases.

Courtesy, UT E&PP

Figure 9-8. Multiple-catch trap for mice.

Ectoparasites of pigeons, starlings and house sparrows can invade buildings. Some of these parasites bite and irritate humans. A long list of mites infests pigeons, but the northern fowl mite and chicken mite are usually the main culprits invading buildings from nesting and roosting sites.

Native bird species are protected by federal and or/state laws and regulations. Non-target birds in treatment areas may be protected and any actions that kill or damage protected birds or their habitats are a violation of various federal and state regulations. Pigeons, starlings and house sparrows are non-native and are not protected except in areas that have established "bird sanctuaries." Nonetheless, applications of toxicants or repellents must be according to the product label and under the restrictions that apply under FIFRA. Because blackbirds (including grackles and cowbirds) and crows are considered migratory birds, they are protected under the Federal Migratory Bird Treaty Act; however, they may be harassed or killed when "committing or about to commit depredations upon ornamental or shade trees, agricultural crops, livestock or wildlife, or when concentrated in such numbers and manner as to constitute a health hazard or other nuisance," as stated in federal laws regarding migratory birds.

Pigeons

The domestic pigeon (*Columba livia*) has become the most serious bird pest associated with buildings, where they may congregate in large flocks. Although primarily seed or

grain eaters, in urban areas pigeons feed on garbage, spilled grains, insects, food left by outdoor diners and food provided by bird lovers who intentionally feed pigeons.

Roosting sites, protected from the elements, are used for nesting, congregating at night and shelter in bad weather. Pigeons prefer flat and smooth surfaces on which to rest and feed and, unlike most birds, they will feed from rooftops, regardless of height, because they like openness that permits a speedy escape. Building roofs and ledges, cooling towers, bridges and signs are typical roosting and loafing sites, whereas they feed in parks, squares, food loading docks, garbage areas, railroad sidings, food plants and wherever people eat outdoors.

Male and females share incubation responsibilities for the one or two eggs produced City pigeons generally remain in one area year-round and can produce 10 young per year. Nests that are continually used become solid with droppings, feathers, debris and sometimes, dead birds. Life span is highly variable, ranging from three to 15 years in urban roosts and up to 30 years in captivity.

Starlings

Starlings are robin-sized birds that weigh about three ounces. They nest in holes or cavities in trees or in rocks, or in urban areas on buildings, in birdhouses, on power stations and water towers and other structures. Starlings usually produce two broods a year with four to seven young per brood. Both parents build the nest, incubate the eggs and feed the young, which leave the nest when they are about three weeks old.

Starlings migrate in some parts of the country. As cold weather begins in the fall, they begin forming larger flocks. The major sources of food shift from insects and fruits to grains, seeds, livestock rations and garbage. Rural and suburban roosting areas may shift into cities and towns. Each day they may fly up to 30 miles to their feeding sites. Each starling eats about one ounce of food daily. Leaving their roost at sunrise, they travel to feeding sites over well-established flight lines. Instead of flying straight into the roosts when returning just before sundown, they "stage" on high perches such as trees, power lines, bridges and towers. The birds are quite social at these times and remain on pre-roost sites until after sunset, singing and calling to each other.

Starlings are pests because of their high numbers. Thousands or tens of thousands can roost at one site. Droppings at the roost site damage car finishes, tarnish buildings, drop on people below and build up to such levels that they become a health hazard; starlings have been responsible for outbreaks of a number of diseases. When starlings roost in food processing plants or storage areas, they contaminate food. The birds are noisy, consume large quantities of livestock feed and contaminate water at stockyards.

House sparrows

The house sparrow (*Passer domesticus*), also called the English sparrow, now flourishes all over the continental U.S. except in heavy forests, mountains and deserts. Sparrows seem to prefer human-altered habitats in cities and around farm buildings and houses.

House sparrows average three broods per season with four to seven eggs per brood. Nests, bulky and roofed over, are located in trees and shrubs, on building ledges, in signs, on light fixtures and under bridges. The nests often plug rain gutters or jam power transformers.

Sparrows are aggressive and social birds, often out-competing native species. They have no recognized migration patterns and will stay in an area as long as food and nest sites are available. Sparrows are very tolerant of human activity and will not hesitate to set up housekeeping in high traffic areas. They feed preferentially on grain and also on fruits, seeds and garbage and can be pests in many situations. Their droppings contaminate stored grain and bulk food. Droppings and feathers can make hazardous, unsanitary, and smelly wastes inside and outside of buildings, on sidewalks and under roosting sites. Sparrows also can become pests when one or a few begin nesting inside a food plant, warehouse, mall, or atrium.

The birds cause damage by pecking at rigid foam insulation in buildings and nesting inside traffic lights. They create fire hazards by nesting in transformers and power stations. They are a factor in the transmission of a number of diseases, internal parasites and ectoparasites.

Other birds

Other birds, from vultures to cormorants, may occasionally cause unexpected and unusual pest problems or serve as reservoirs of disease organisms. When blackbirds and crows roost in suburban areas they become pests. Woodpeckers can "hammer" into house siding looking for insects or calling mates. Gulls can feed at food plants, landfills, etc. These birds, however, are more protected by laws and regulations than the three species discussed previously.

Detection and Control

Inspection Surveys should be conducted early in the morning, midday and again in the evening to construct an accurate account of the problem and the different activity periods in order to minimize risk. The survey should document both the target and non-target species involved, census the target population and identify bird status as to resident, migrant, adult or juvenile. An attempt should be made to identify the activity as feeding, roosting, nesting or loafing, determine sources of food and liquids, and estimate health and damage risks presented by their presence. To assess control options, it is helpful to determine what attracts the birds to the site, what non-targets are resident, where they might disperse to and if exclusion or habitat modification is a viable option. Public relations and legal ramifications should not be overlooked.

Habitat modification Habitat modification for birds means limiting a bird's food, water, or shelter, which for pigeons, starlings and house sparrows is not practical as these birds will have a number of feeding and watering sites -- often far from roosting and loafing areas. Pigeons, but not sparrows or starlings, may be induced to move by the persistent destruction of nests and eggs. Landowners should refrain from topping their trees as this creates dense foliage, which entices roosting blackbirds.

Exclusion Some building designs and conditions lend themselves to bird infestation. Flat ledges, openings in water towers and vents, unscreened windows and other attributes make a building an attractive location for roosting, nesting and loafing. Modification or repair can exclude birds. Typical

solutions include replacing broken windows and screens, eliminating large crevices, and blocking openings into vents, cooling towers and roof-top equipment with hardware cloth. The following specific measures should be considered because the control is usually long-lasting.

Netting. Netting can be used to block access of birds to large roosting areas in structures, especially in warehouses and around mechanical equipment areas and cooling towers where aesthetics are of minor consideration. Netting is also used to protect fruit-bearing trees and shrubs and to prevent woodpeckers from hammering on sides of houses and other buildings. Knotted or extruded, UV-resistant plastic nets will last two to five years.

Covers or ramps. Covers or ramps custom-designed for ledges, window air conditioning units and roof edges keep birds from infesting these sites. This is costly but valid where limited application will keep birds off selected sites and where aesthetics are an important consideration.

Spikes. Porcupine wire, sharp metal spikes, or any similar "bed of nails" can stop birds from roosting on ledges (Figure 9-9). Where they can be used, they usually work fairly well. If aesthetics are important, these devices can be limited to areas where they cannot be easily seen. Check every six months for accumulated debris or nest material, regularly remove leaves and other matter and ensure that no tree branches hang over protected ledges.

Sticky repellents (polybutenes) and foot irritants. Tacky gels and liquids are designed to be sticky enough to make a bird uncomfortable, but not so sticky that the birds are trapped. Foot irritants create discomfort to birds' feet causing them to move in search of another loafing area. The surface must be appropriately prepared to provide suitable service. After a few attempts, the birds stop trying to land on treated surfaces. Polybutenes are useful in keeping woodpeckers and other birds off houses and decks. Foot irritants are used on perches to repel pigeons and other perching birds.

Ultrasonic sound devices. These devices do not work against birds.

Trapping. Trapping can be an effective supplemental control measure, especially against pigeons. Where a group of birds is roosting or feeding in a confined and isolated area, trapping should be considered the primary control tactic, preferably in the winter when food availability is at a minimum. Starlings are not usually good candidates for trapping programs, but effective sparrow traps are available.

Avicides. Baiting with chemicals that have flock-alarming properties can control many species of birds when using specific bait formulations (whole corn for pigeons, smaller grains for sparrows and other birds). Within 15 minutes of eating a toxic dose, birds become intoxicated and most die within a few hours. Only 5 to 15 percent of the flock needs to be affected as the flock becomes frightened and most will leave the area.

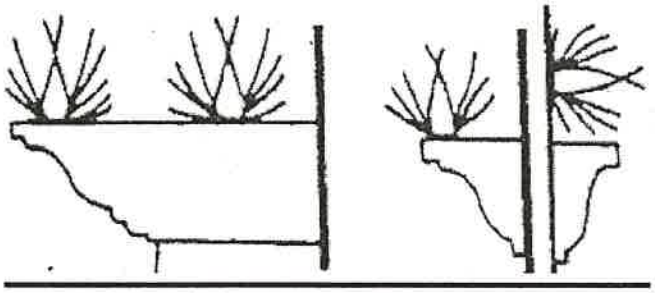


Figure 9-9. Bird spikes

Shooting. A possible alternative or supplemental method for eliminating birds is shooting. Shooting pigeons off the roost at night with a high-powered pellet gun is particularly effective. Shooting a shotgun in the evening as blackbirds come to roost is effective in moving the roost if done repeatedly for five to seven days. Shooting is not an effective or efficient method of reducing large flocks of problem birds, such as grackles, starlings or house sparrows. Follow all gun regulations.

Non-target risk. Most lethal tactics in bird control pose some risk to non-target birds, as well as other animals. Non-targets are protected by various federal, state and local regulations. Minimize the threat by first identifying the non-targets in the area, using tactics that are least risky and monitor operations to be sure no non-targets are being adversely affected.

Public relations. Some people may react more negatively to one dying bird than to accumulated pigeon droppings on sidewalks or potential risks of parasites and disease from bird roosts. Pigeons and house sparrows are seen as pets rather than pests. The public's perception of bird management operations should be considered. All bird management programs should put some effort into avoiding "people problems" -- particularly when using toxic control techniques.

Bird dropping removal and clean-up. Workers removing large quantities of bird droppings should follow certain precautions to minimize risk from disease organisms in the droppings. Wear a respirator that can filter particles down to 0.3 microns and disposable protective gloves, hat, coveralls and boots. Wet down the droppings to keep spores from becoming airborne and keep wet. Put the droppings into sealed plastic garbage bags and wet down the outside of the bags. When finished, and while still wearing the respirator, remove the protective clothing and place them in a plastic bag. Dispose of trash bags (disposal should be permissible through standard trash pick-up). Wash up or shower.

Bats

Bats are highly beneficial wild mammals. Bats are more closely related to primates (monkeys and humans) than they are to rodents. All these bats feed on night-flying insects. Each bat eats about its weight in food every night. 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 like some birds do, 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 food to fly. Most bat species only have one baby per year. Bats are long lived animals. The little brown bat from the northern states 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 dogs, cats, raccoons and skunks. But unlike these animals, rabies-infected bats do not generally become enraged and attack people or other animals.

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.

Management

Removing Single Bats from a Building. 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.

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. The 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 that are deposited around the opening as bats enter or leave the 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.

Bat Proofing. As with most nuisance animal situations, preventing a problem is much easier and cheaper than correcting one. 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 silicon rubber chalk. 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 (Figure 9-10).

Excluding a Bat Colony. When bats do 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.
3. Plan to do the exclusions in the spring or fall. Bats give birth in the summer.
4. Exclude the unwanted bats by placing one-way devices, such as the plastic sleeve in Figure 9-11, on each of the colony's exit points.

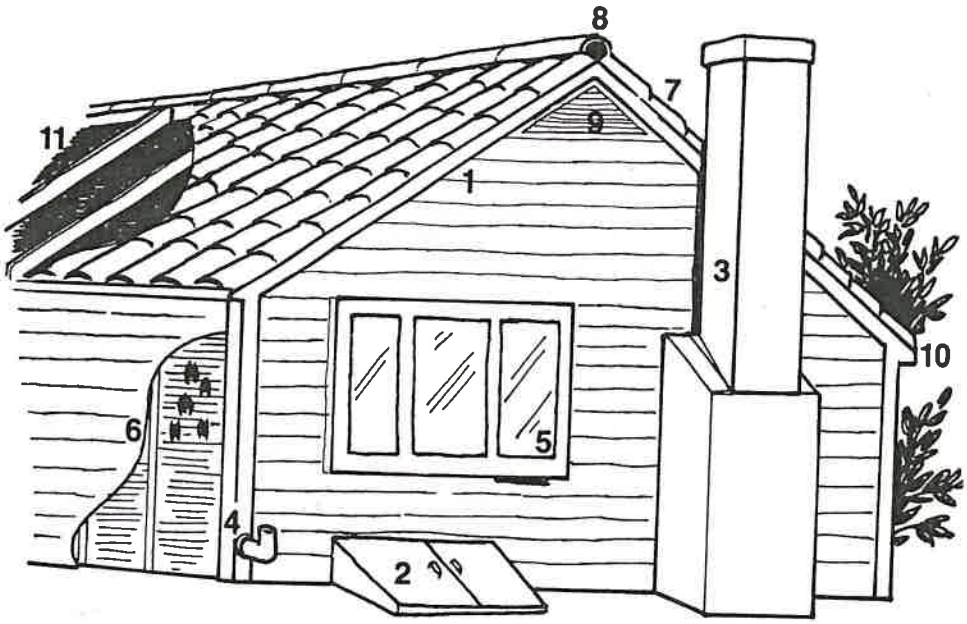


Figure 9-10. Common points of entry and roosting sites of bats in buildings.

5. Apply insecticidal dusts or sprays to control external parasites, such as bat bugs, soft ticks or mites, once bat colony is excluded.
6. Spray bat guano with water and remove while using proper protective equipment including a cartridge respirator that filters 0.3 microns.
   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.
7. Permanently seal roost openings when you are sure that all of the bats have left the roost.

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.

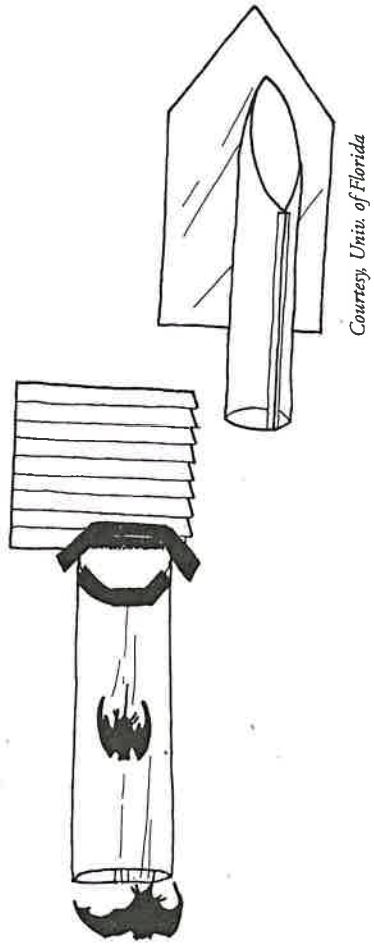


Figure 9-11. Plastic sleeve used as one-way device to exclude bats.

Tree Squirrels

Several species (*Sciurus* spp.) of tree squirrels have adapted well to suburban and city life. Occasionally, these squirrels enter buildings and cause damage or disturbance. The most common species that become pests are the gray squirrel, red squirrel, flying squirrel and fox squirrel. Tree squirrels usually build their nests in trees, but they also may store food and find shelter in attics and garages. Probably the primary way squirrels become pests is by scrambling and scratching inside attics and in wall voids. They may travel on power lines and short out transformers. They like to gnaw on wires.

Control and management. The first step in eliminating a squirrel problem in a building is to find out where the squirrels are entering. Common points of daily entry include damaged attic louvers, ventilators, soffits, joints of siding, knotholes, openings where utility wires or pipes enter, chimneys and flashing. Use heavy gauge 1/2-inch hardware cloth or sheet metal to seal most openings. Make other suitable repairs as for rat-proofing. Tree branches should be trimmed back 10 feet from the building. Sticky repellents, similar to those used in bird control, may be used to keep squirrels off houses, decks and other structures.

Live trapping with box or wire traps can be used to remove one or a few squirrels from a building. Traps should be left open and unset for a few days, surrounded by bait, so the squirrels get used to them. Good baits include peanuts, nutmeats, peanut butter, whole corn, sunflower seeds, or rolled oats. Then the trap can be set. Good trap locations include the roof, the base of nearby trees, or in the attic itself. Squirrels are nasty biters and should be handled carefully. Captured squirrels should be killed by shooting, blunt trauma or drowning. Rat snap traps can be used to kill squirrels in attics. The bait should be tied to the trigger and the trap nailed or wired to a beam.

It is illegal to release a trapped animal onto someone else's property, including state property, without permission.

Skunks, Raccoons and Opossums

These vertebrates are considered together because they are similar pests with similar management and control recommendations. Management of these animals almost always involves exclusion and/or trapping.

Skunks (*Mephitis* spp.) are nocturnal. They do not hibernate but may sleep through cold weather periods. They usually live in underground burrows, hollow logs, or rock piles. They may decide to live under houses, decks, sheds, cabins, or storage buildings. The main problem with skunks is their odor. They become pests when they change their dietary selections from rodents, insects and wild fruit to garden crops, garbage and lawn insects, and locate their habitat closer to humans. Raccoons (*Procyon lotor*) are common throughout North America. They are easy to recognize with their black face mask and ringed bushy tail. They have long, thick fur with a thin muzzle and pointed ears. Their feet are well adapted to climbing.

Raccoons den inside hollow trees or logs, rock crevices, deserted buildings, culverts, storm sewers, chimneys, attics and

crawl spaces. Winter months are spent near the den, but they do not hibernate. They become active during warm spells. In the spring and summer, they feed on crayfish, mussels, frogs and fish. In the fall, they switch to fruits, seeds, nuts, grains and pet foods. They also eat mice, squirrels and birds and are quite happy knocking over a garbage can. Raccoons can transmit rabies and have been implicated in the West Nile virus cycle.

Opossums, which are related to kangaroos, are the only North American marsupial. The "possum" is a whitish or grayish animal the size of a house cat with a naked, rat-like tail. Its face is long and pointed with rounded, hairless ears. They den in the burrows of other large animals, and in tree cavities, in brush piles and under sheds and buildings. Occasionally, they move into attics and garages. They eat nearly everything, from insects to carrion, fruits to grains, garbage to pet food. Opossums are active at night. When threatened, opossums climb trees or go down into burrows. If cornered, they may growl, hiss, bite, screech and exude a smelly green fluid from their rear end. If these defenses aren't successful, they may play dead. The main complaint against opossums is that they get into garbage, bird feeders, or pet food left outside.

Control and management. The best preventive measure for skunks, raccoons and opossums is to establish a good level of sanitation in a neighborhood.

These animals can be prevented from entering buildings by repairing breaks in foundations and screening crawl space vents with hardware cloth. If the animal is currently living under the building, seal all openings but one, then sprinkle a tracking patch of talc at the opening. Examine the area after dark. If tracks show that the animal has left, close this last opening immediately. Seal attic openings and cap chimneys with a wire cage or other animal-proof cover.

The best way to remove animals from around buildings is by trapping or shooting. Ensure no gun laws or regulations are violated. If the animal is live-trapped, be prepared to kill, handle, and/or release it. It is illegal to release a trapped animal onto someone else's property, including state property, without permission.

Set traps as close to the den as possible or place them where damage is occurring, e.g., at corners of gardens or breaks in stone walls, or along obvious animal trails. Set multiple traps in a number of locations. Since these animals are active at night, check traps at least every morning, preferably twice a day. Check traps often to spot and release non-target animals. Skunks don't like to "spray" if they can't see their target, so cover all but the trap entrance with burlap or canvas before placing the trap, or use a commercial skunk trap. Approach the trap slowly and transport it gently. To release a trapped skunk, stand more than 20 feet away and release the trap door using a string or fishing line. The best baits for skunks are chicken parts and entrails, fresh fish, cat food, sardines and eggs; for raccoons, chicken parts and entrails, corn, fresh fish and sardines; for opossums, apple slices, chicken parts and entrails, fresh fish and sardines.

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 9-12).

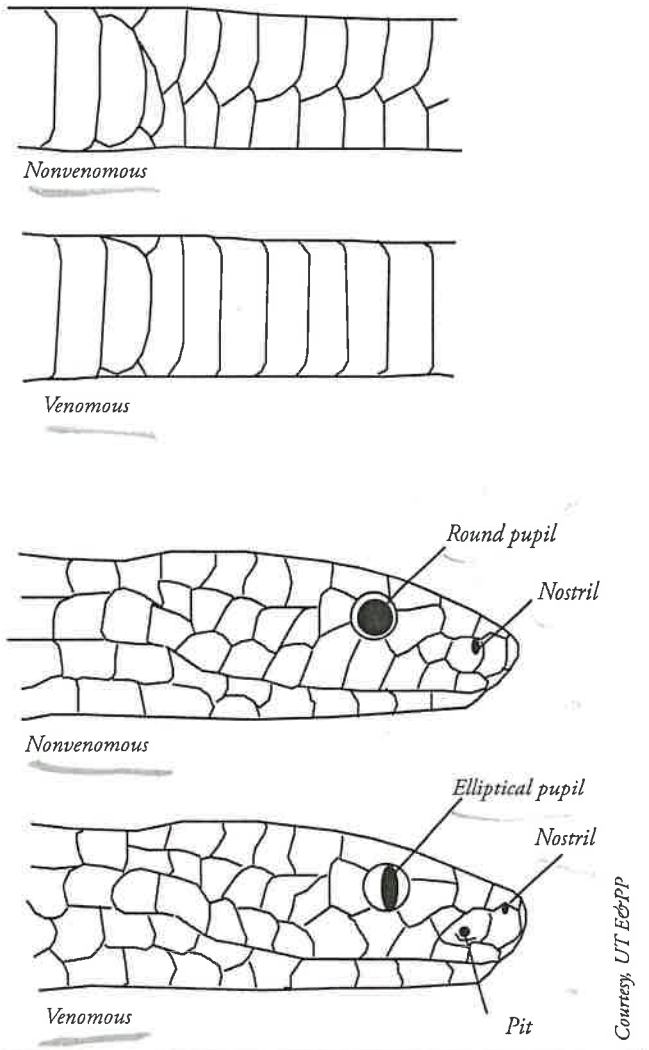


Figure 9-12. Characteristics to distinguish between venomous and nonvenomous snakes.

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. Vegetable oil is used to dissolve the glue and release the snake unharmed once the snake has been relocated.

Review Questions

1. Rats can compress their body and squeeze through an opening as small as _____.
   - A. 1/4 inch diameter
   - B. ½ 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. 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.

6. 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.

7. 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

8. When working in an area where bat guano is present, one should _____.
   - A. wear protective clothing
   - B. cartridge respirator that filters 0.3 microns
   - C. Spray the guano with water before removing
   - D. all of the above

9. Scientific evidence exists to prove ultrasonic sound emitters control bats.
   - A. True
   - B. False

10. 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. an 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. D, 6. B, 7. D, 8. D, 9. B, 10. B

Chapter 10 Wood-destroying Organisms

To successfully prevent or control wood damage, you must first be able to identify wood-destroying organisms and understand their habits and behavior. Only then can their populations be targeted and conditions that are contributing to their success eliminated.

Wood-inhabiting fungi are small organisms that lack chlorophyll and use wood as their food source. Some fungi use only starch and proteins in the wood and don't weaken it. Others use the structural components, and as they grow they weaken the wood, which eventually becomes structurally useless. All fungi require moisture, oxygen, warmth and food. The keys to preventing or controlling growth of fungi in wood buildings are to keep the wood dry at all times (below a moisture content of 20 percent), use pressure-treated wood, or naturally resistant heartwood. Wood that will be in contact with the ground during use should be pressure treated.

Wood-inhabiting insects can be divided into those, such as termites and wood-boring beetles, which use wood as a food material and those, such as carpenter ants and carpenter bees, which use it for shelter. Pressure-treated wood is resistant to attack by all the insects. Other prevention and control techniques depend on the type of insect.

You must know how to distinguish between damage caused by fungi and insects. Correct pest identification and knowing the extent of infestation is essential before any control measures can be applied. Different insects require different types of management programs. Information is provided below to help make a correct diagnosis. If you still have doubt about the cause of wood damage, bring a specimen, call or visit your county Extension agent or other expert. See the Appendix about University of Tennessee Extension Distance Diagnostics.

Surface Molds and Sapstain Fungi

Surface molds or mildew fungi discolor the surface of wood, but do not weaken it. They are generally green, black or orange and powdery in appearance. Spores (or seeds) of surface molds or mildew fungi grow quickly on moist wood, or on wood in very humid conditions. They can grow on wood before it is seasoned, when it is in the supplier's yard, on the building site or in a finished house. When the wood dries, the fungi die or become dormant, but they do not change their appearance. Surface molds and mildew fungi are controlled by eliminating the source of high humidity or excess moisture, for example by repairing leaks, improving ventilation in attics or crawl spaces, or installing soil covers. If the wood is dry and the sources of moisture are no longer present, no corrective action need be taken.

Sapstain or bluestain fungi are similar to surface molds, except that discoloration goes deep into the wood. They color the wood blue, black or gray and do not weaken it. They grow quickly on moist wood and do not change their appearance when they die or become dormant.

Stain fungi are an indication that the wood has remained in a high humidity or damp environment for an extended time period. Often these stains have occurred in the manufacturing process and are not an indication of the current conditions. If mold, mildew, or other fungus is present then a moisture problem currently exists and should be taken care of. Control is the same for molds or mildew fungi.

Wood Decay Fungi

A wood-decaying fungus is an organism that cannot make or capture its own food. Therefore, it must "feed" off other materials such as wood. Severe wood decay occurs only in wood with a moisture content greater than 20 percent. Most wood decaying-fungi grow only on wood subject to wetting by rain, roof leaks, plumbing leaks, condensation or contact with moist soil. However, some fungi have water-conducting structures that actually bring water into the wood.

Brown and White Rot. Brown rot more commonly attacks softwoods and white rots more commonly occur in hardwoods; however, both brown and white rots occasionally colonize both types of wood. Brown and white rot are caused by fungi that decay wood and reduce its strength. The fungi often produce a whitish, cottony growth on the surface of wood. They grow only on moist wood. The fungi can be present in the wood when it is brought into the house, or can grow from spores that are always present in the air and soil.

Wood decayed by brown-rot fungi (Fig. 10-1) is brittle and darkened. As decay proceeds, the wood shrinks, twists and cracks perpendicular to the grain. Finally, it becomes dry and powdery. Brown rot is the commonest type of decay found in wood in houses.

Wood decayed by white-rot fungi (Fig. 10-2) is fibrous and spongy, and is bleached. Sometimes it has thin, dark lines around decayed areas. The wood does not shrink until decay is advanced.

Water-Conducting Fungi. Most decay fungi are able to grow only on moist wood and cannot attack adjacent dry wood. One brown-rot fungi, *Meruliporia incrassata,* is able to conduct water for several feet through root-like strands or rhizomorphs, moisten wood and then decay it. These are sometimes called water-conducting or dry-rot fungi. They can decay wood in houses very rapidly, but fortunately they

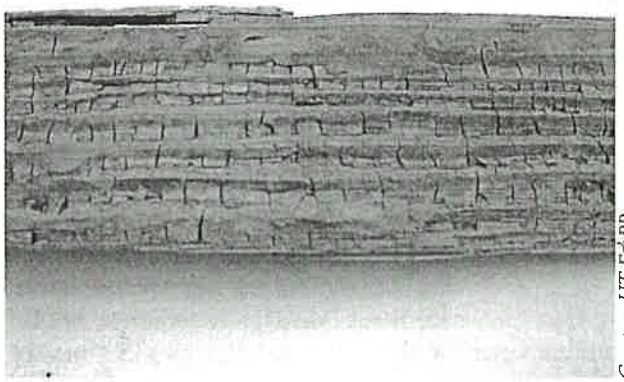
are quite rare. *Meruliporia incrassata* is found most frequently in the Southeast. *Meruliporia* can cause extensive damage in floors and walls away from obvious sources of moisture. Decayed wood has the characteristics of brown rotted wood except that the wood's surface sometimes appears wavy but apparently sound, although the interior may be heavily decayed. The rhizomorphs that characterize these fungi can be up to an inch in diameter and white to black depending on their age. They can penetrate foundation walls and often are hidden between wood members. *Meruliporia incrassata* normally occurs in new or remodeled houses and can cause extensive damage within two to three years.

Wood-Decay Fungi Control

The fungi can be controlled by eliminating the source of moisture that allows them to grow by improving drainage and ventilation under a house or in an attic, installing soil covers or vapor barriers, repairing water leaks or preventing water seepage and eliminating contact between wood and soil. When the wood dries, the fungi die or become dormant. Treating the wood with chemicals, such as borates, will help to treat the symptoms of the problem, but not the cause. The source of moisture must be removed to prevent further fungal infestation. Seriously damaged members should be replaced. If moisture cannot be controlled or wood is used in areas of ground contact or high moisture, then pressure-treated wood should be used. Borates are labeled for fungal control of wood in-service. Most often in-place treatments are not used because the decay has not been detected until after significant damage to the wood has occurred.

Termites

Termites are small white or brown insects that live in colonies within soil or wood. They require wood, wood products or other forms of cellulose for food. Colonies often live in stumps and decaying logs, but are capable of invading buildings and feeding on structural wood. Subterranean termites are the most serious and destructive pests of wood structures in the United States.



Courtesy, UT Ext-PP

Figure 10-1. Wood damaged by brown rot cracks perpendicular to the grain.

You must first know the identity of the pest before beginning a control program. Many people confuse winged termites with flying ants. Both swarm near structures. You can tell them apart by comparing three physical characteristics (Figure 4-1).

Winged termites (alates or swarmers) have

- straight antennae,
- thick waists, and
- four, long, fragile wings of equal size and shape.

Termites belong to the insect order Isoptera, which means equal wings.

Winged ants have

- elbowed antennae,
- a wasp-like body shape (narrow waist), and
- two front wings that are larger than the two hind wings.

Three types of pest termites occur in the United States: dampwood, drywood and subterranean termites. Excellent pictorial keys have been produced that aid in identification of subterranean, drywood and dampwood termites (See Appendix).

Dampwood Termites

Dampwood termites are not known to occur in Tennessee. In general, their distribution is limited to coastal areas of the southern states where they infest wood saturated with water. Controlling excess moisture alone may successfully eliminate these pests.

Drywood Termites

You will rarely find drywood termites in Tennessee. When you do, you can usually trace their origin to furniture or other wood moved into Tennessee from tropical countries or southern regions of the United States. Drywood termites require very little moisture, so they live within the wood and have no connection to the soil. As they feed, they cut across the grain of wood, excavating large galleries connected by small tunnels. They produce small, cylindrical fecal pellets with six distinct depressions on the sides (Figure 10-3). These frass pellets are unique to drywood termites and are used for identification. The termites may push these pellets out of the infested wood through small holes where the pellets are often found by the homeowner.

Courtesy, B. Bond, UT F,FO-W

Figure 10-2. Wood damaged by white rot is fibrous, spongy and bleached.

Drywood termite alates can be identified by two pair of hairless, membranous wings that are about equal in size and shape and have three or four darkened veins (subcosta and branches of the radial sector) in the leading (costal) margin of each wing (Figure 10-4). Soldiers of drywood termites either have a rectangular head, such as *Kalotermes approximatus* (Figure 10-5), or a dark, plug-shaped head, such as in *Cryptotermes brevis* (Figure 10-6). If the head is rectangular, the drywood termite's pronotum is equal to or greater in width than the head capsule (Figure 10-5). *Cryptotermes* species are called powderpost termites because they reduce wood to a "powder." They are smaller than most drywood termites.

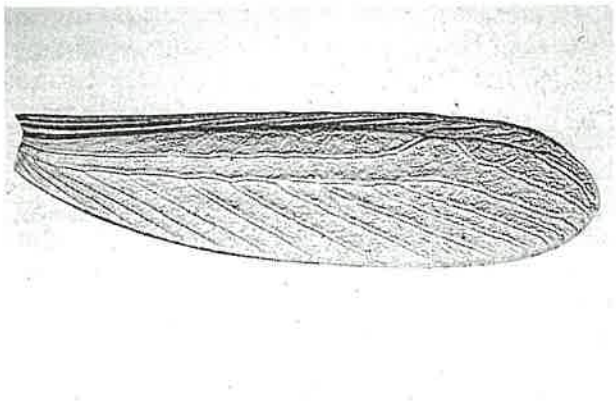
Most drywood termite infestations in Tennessee are confined to a piece of wood furniture or specific area like a windowsill, baseboard or floor joist. Careful inspection of used furniture and other wood objects brought into the home and the use of pressure-treated wood are good ways to prevent an infestation.

Several methods are used to treat localized infestations of drywood termites. Local or "spot" treatments for drywoods include injecting wood and surface applications, using microwave energy or electrocution, and wood replacement. Insecticide can be injected into small holes drilled to intersect termite galleries. This is called wood injection or a "drill-and-treat" application and is the simplest and most direct method of treatment. Spray and foam applications of products such as those containing disodium octaborate tetrahydate (DOT) can be applied to raw, uncoated wood surfaces. Because penetration depths of borate solutions and depth of drywood termite galleries vary, topical applications with drill injection into infested wood should be performed. Trailer or chamber fumigation may be used for smaller items such as furniture.

If the drywood termite infestation is extensive, fumigation may be the only effective treatment method. Fumigation requires that the structure or wood article be tented and treated either with a toxic gas or with heat. To fumigate a structure with toxic gas, you must be under the supervision of a person licensed in structural fumigation (FUM) and certified in category 7. However, you do not need a separate certification to use heat fumigation. Heat fumigation is a non-toxic method used to control drywood termites. It works by maintaining temperatures high enough to kill termites in a wood object or structure. Heat treatments are used for a portion of a house such as an attic, porch, bedroom or individual apartment in a multi-family dwelling. Beware, high temperatures can damage heat-sensitive objects inside the home. More information on drywood termites can be found at the University of Florida Featured Creatures Web Site at http://www.ifas.ufl.edu/~insect/.

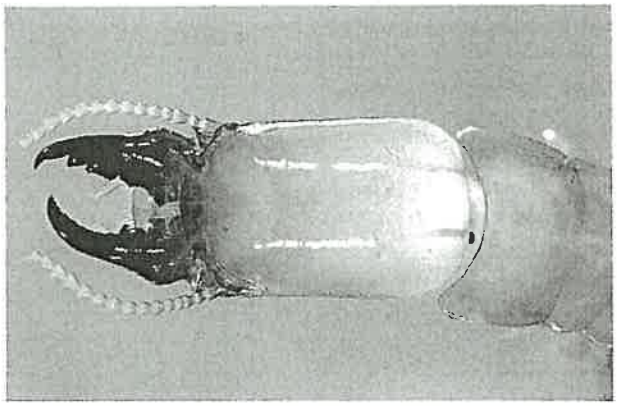
Courtesy, UT EcoPP

Figure 10-3. Drywood termite fecal



Courtesy, R. Scheffrahn, U. of Fla.

Figure 10-4. Drywood termites have three to four darkened veins along the leading edge.

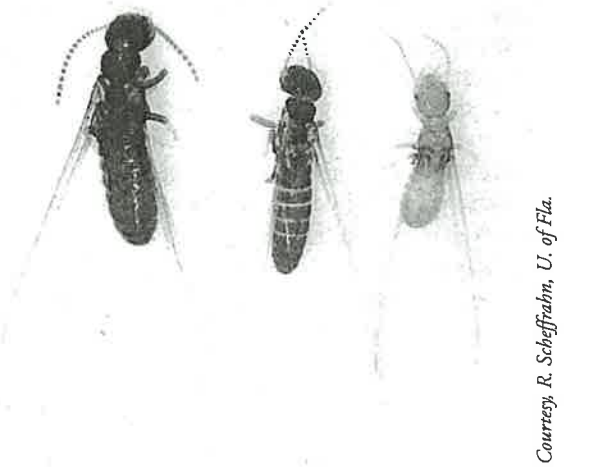


Courtesy, R. Scheffrahn, U. of Fla.

Figure 10-5. Rectangular head of the drywood termite, *Kalotermes approximatus.*

Courtesy, R. Scheffrahn, U. of Fla.

Figure 10-6. Dark, plug-shaped head of the powderpost termite, *Cryptotermes brevis.*



Courtesy, R. Scheffrahn, U. of Fla.

Figure 10-7. Comparison of three native subterranean termites, *Reticulitermes flavipes*, *R. virginicus* and *R. hageni*.

Subterranean Termites: Biology and Identification

Subterranean termites of the family Rhinotermitidae occur throughout Tennessee and are the most common termite infesting structures. Subterranean termites have strict moisture needs and therefore nest in the soil and forage underground. They can attack any untreated wood in contact with the soil. If there is no direct wood-to-soil contact, the termites can use the soil to build tunnels (mud tubes or shelter tubes) within the cracks of foundations or over the outside of concrete.

Part of the termite's moisture comes from their metabolism. The rest comes from soil moisture that diffuses throughout their tunnels or tubes. Occasionally, subterranean termite infestations are found above ground, isolated from the soil. This can occur if moisture is available from a source other than the soil. Common sources of moisture include leaky pipes, air conditioning units, condensation build up within the walls or flat roofs that collect debris.

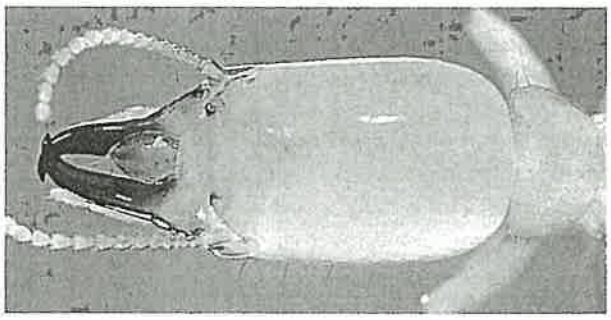
Wood is mostly made of cellulose. Few animals have the necessary body chemistry to break down cellulose into smaller, more usable nutrients. Termites can accomplish this because they have protozoa in their hindgut (intestinal system). These protozoa break down the cellulose into products that the termites can digest. If the protozoa are removed, the termites will eventually die of starvation.

The most important and most prevalent subterranean termite in Tennessee is the eastern subterranean termite, *Reticulitermes flavipes* (Fig. 10-7). This species is common throughout the southeastern United States. Two less common subterranean termites in Tennessee are the southeastern subterranean termite, *R. virginicus* (Fig. 10-7); and the light southeastern subterranean termite, *R. hageni* (Fig. 10-7).

Colony Structure. Subterranean termites live in colonies below ground. The subterranean termite colony contains specialized groups of termites called "castes." Each caste performs certain jobs or functions. Three castes of subterranean termites are (1) worker, (2) soldier and (3) reproductive.

Courtesy, U. of Fla.

Figure 10-8. Worker subterranean termites.



Courtesy, R. Scheffrahn, U. of Fla.

Figure 10-9. Soldiers of *Reticulitermes flavipes* (pronotum width >0.9 mm).

Workers

Worker (Fig. 10-8) termites are creamy-white, wingless and eyeless insects. They are by far the most numerous in the colony. Their primary function is to perform the actual work of the colony: forage for food, maintain galleries within the wood, tend the young, and groom and feed the king, queen and soldier termites. Termite workers are the caste most commonly seen in infested wood. Because of their small size and large numbers, they are sometimes misnamed 'white ants.'

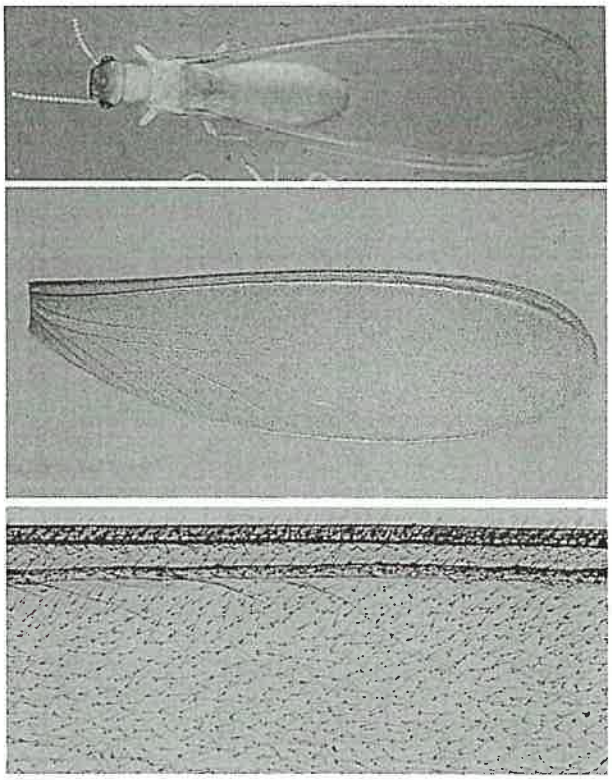
The workers maintain shelter tubes of mud and fecal material when foraging above ground. They close any breaks in infested wood with the same material. The mud tubes also serve as a protective barrier against their natural enemies, especially ants. These typically sterile termites spend their three- to five-year life spans contributing only their work to the colony.

Soldiers

Termite soldiers are easy to identify because they are wingless, have greatly enlarged golden-brown heads and sword-like mandibles (jaws) (Fig. 10-9). There are a relatively small number of soldiers in a colony. The soldier's job is to guard the colony against predators, primarily ants. The soldiers are so specialized that they cannot feed themselves, so the workers feed them. Termite soldiers are sterile. Soldiers mature within one year and live three to five years.

Primary Reproductives

Primary reproductives are the future kings and queens of new subterranean termite colonies. The primary reproductives



Courtesy, R. Scheffrahn, U. of Fla.

Figure 10-10. Formosan subterranean termite alate, wing and enlarged wing showing hairs.

are produced in mature colonies (typically three to five years and older). During the swarm season, large numbers of these reproductives swarm out of their colonies and into the air. Frequently, a homeowner's first indication of termite infestation is having a swarm take place inside his/her home. Primary reproductives that fly are called 'swarmers." *R. flavipes* often flies between March and May, while *R. virginicus* typically flies April through June. *R. hageni,* a pale-brown species, may fly from late July through late September.

Secondary Reproductives

Secondary reproductives or neotenics are also present in mature and growing colonies. Secondary reproductives may supplement egg production in the presence of the king and queen. Secondary reproductives can become an important egg source and collectively can produce more eggs than the primary female. These reproductives are formed if the queen or king dies or begins to fail, or if these individuals become isolated from the main colony. Isolation from the main portion of the colony can occur due to application of a repellent termiticide (which separates above-ground individuals from those below ground); flooding; drought; physical disruption of the soil, such as during construction; and other causes. Both male and female secondary reproductives may have wing pads, but never full wings, and will never leave the colony.

Larvae and Nymphs

The white, youngest immatures are called larvae. If they continue to grow without developing wing buds, these immatures are also called larvae. These immatures must be fed a liquid diet by other nestmates. When the immatures develop wing buds, they are then referred to as nymphs.

Characteristic	Formosan Subterranean	Native Subterranean
shape of soldier head	oval	rectangular
wings	hairy	nearly bare
% soldiers in colony	20-30	1 -3
swarm time	dusk to midnight	day
alate color	yellow- brown	dark brown (R. flavipes or R. virginicus) or yellow-brown (R. hageni)
length of alates including wings	12 - 15 mm	7 - 10.5 mm

Table 10-1. Comparison of Formosan and native subterranean termites.

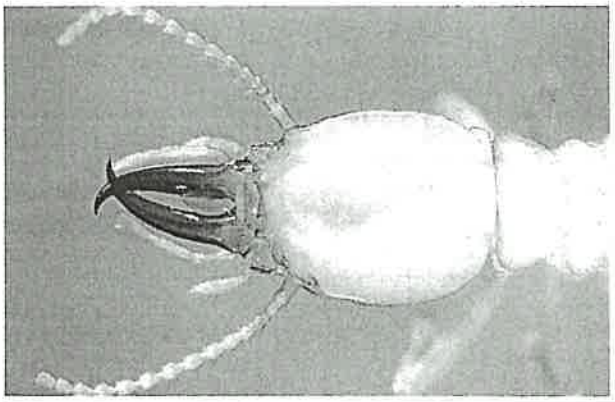
Colony Formation. The swarm is a mating dispersal flight that usually contains equal numbers of both male and female reproductives. After flight, they land, break off their wings and seek out a nest site. Subterranean termites usually excavate a burrow under trees, in decaying wood or in the soil. Swarmers that emerge indoors will die in large numbers around windows in their efforts to escape.

Once the new king and queen find a nest site, they seal themselves in and mate. Then the queen will begin to lay eggs. The first batch will be small, usually between six and 24 eggs. As the colony grows, the queen will lay increasingly larger numbers of eggs. When the queen is mature, she may lay 5,000-10,000 eggs per year.

In three to five years, the newly established colony may reach a mature size of 60,000 termites or more. At this point, secondary reproductives may begin to develop. The colony will increase even more rapidly as the secondary reproductives start to lay eggs. As the colony forages over larger areas, satellite colonies develop that contain secondary reproductives rather than a single queen. Sometimes a number of individuals, including one or more secondary reproductives, become isolated from a well-established colony and start a new one. This type of colony formation is called 'budding."

Formosan subterranean termite

The Formosan subterranean termite, *Coptotermes formosanus* (Fig. 10-10, 10-11,), is a more aggressive feeder than the native subterranean termites. The Formosan termite originated in the Far East, probably hitchhiking to the United States in crated material following World War II. It is currently established in Alabama, California (an isolated infestation in San Diego County), Florida, Georgia, Hawaii, Louisiana, Mississippi, North and South Carolina and Texas. It has been introduced to the Memphis area in the past, but is not established. Unlike the other subterranean termites that eat along the grain of the wood, the Formosan termite is less discriminating and will often hollow out a tree trunk or wooden beam. It is estimated that a Formosan subterranean termite colony can consume wood about six times as fast as



Courtesy, R. Scheffrahn, U. of Fla.

Figure 10-11. Formosan subterranean soldier.

an eastern subterranean termite colony. See Table 10-1 for a comparison of Formosan versus other subterranean termites. Formosan termites found in Tennessee should be reported to the Tennessee Department of Agriculture, Division of Regulatory Services.

Collecting specimens for identification

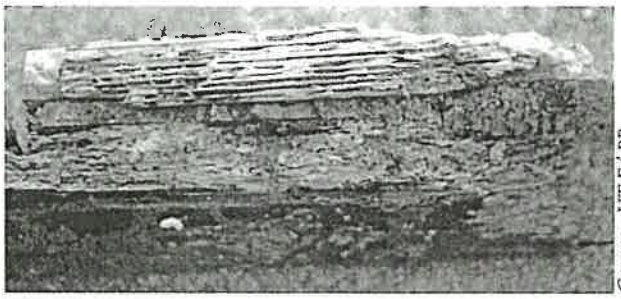
Alates (swarmers) with wings and/or soldiers should be preserved in rubbing alcohol when submitted for identification. Submit at least 10 — 15 specimens. Swarmers without wings and workers are not useful in identification.

Subterranean Termite Detection

Stone or concrete foundations of buildings offer only temporary obstacles to termites. A crack as small as 1/64 of an inch wide will allow termites to enter and move into the wood above. Termites can also build shelter tubes along the foundation to reach wood. Cracks in concrete, continuous openings in building blocks, utility openings, expansion joints and wood below soil level all offer easy hidden access for termites. Once inside, subterranean termites remain hidden within the wood. Termites can be detected by finding

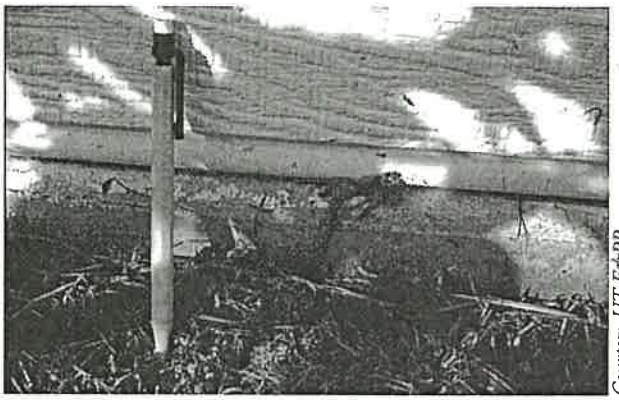
- swarmers emerged inside and attracted to light,
- wood damaged with feeding on the springwood (within the grain) and mud within the layers (Figure 10-12) , and/or
- mud tubes the width of a pencil, about 1/4 to ½ inch wide (Figure 10-13).

Often, damaged wood is unnoticed because the termites leave the exterior surface of the wood intact. You can detect their galleries by tapping the wood every few inches with a screwdriver. Damaged wood will sound hollow and the screwdriver may even break through into the galleries. Inspect buildings at least once a year for evidence of mud tubes. In concrete slab construction, look closely for muddy material in expansion joints, cracks and where pipes and ducts go through the slab. Moisture meters can be used to determine areas of higher moisture content which could be indicative of termite presence. In addition, new termite detection technologies, such as canine termite detectors, acoustic emissions detectors, thermal imaging, microwave technology, etc., are making their way into the commercial workplace, but aren't always widely available at this time.



Courtesy, UT Ed-PP

Figure 10-12. Subterranean termites feed on the springwood and leave mud/frass in these layers.



Courtesy, UT Ed-PP

Figure 10-13. Mud tubes are usually the width of a pencil.

When looking for signs of termite activity, the inspector must also be alert for conditions that favor termite infestations. The most critical condition is wood-to-soil contact. The USDA Forest Service has identified 15 conditions that frequently lead to termite infestations. These conditions either provide a food resource or permit entry through wood-to-soil contact. If any of these conditions exist, inspect the site carefully. Correcting these problems or conducive conditions should be the first step to controlling termites by modifying the environment so it less favorable to termite infestation.

Conditions Leading to Infestation

- Cracks in block or concrete foundations that provide hidden avenues of entry.
- Wooden posts or supports set in concrete in contact with the soil underneath.
- Concrete porches with earth (debris) fill.
- Form boards left in place after the slab is poured.
- Leaking pipes and/or air conditioning drip lines that allow moisture to accumulate at the foundation.
- Shrubs blocking crawl space vents, reducing ventilation and trapping moist air.
- Construction debris in the backfill beside the structure.
- Low foundation walls and footings that allow wood-to-soil contact.
- Stucco, veneer, rigid foam board insulation or other exterior insulation finishing systems (EIFS) carried below graded soil that permits hidden access into the structure and may allow moisture to accumulate.

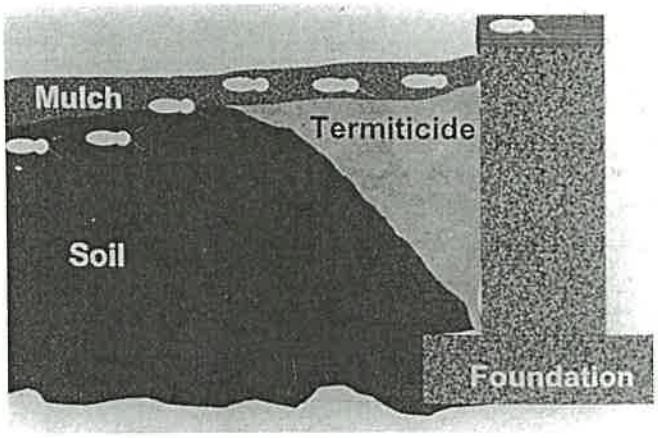


Figure 10-14. Plant-based mulches placed over termiticide-treated soil can give termites access to the home.

- Soil-filled planters built up against the foundation wall, allowing hidden access and moisture accumulation.
- Wooden forms left in the slab around plumbing drains and bath traps.
- Wooden porches or deck supports in contact with the soil.
- Heating units in the crawl space, maintaining warm soil temperatures for termites year-round.
- Paper collars around pipes and ducts, providing access to the structure.
- Wooden fences, trellises and landscaping materials against the side of the structure that allow access and moisture accumulation. Cellulose mulches (wood or bark chips and others of plant origin) placed against the foundation give termites access to the home without having to contact the termiticide barrier that has been applied next to the foundation (Figure 10-14). Leave a 12 to 18-inch plant/mulch free zone next to the foundation.

Subterranean Termite Treatment

Subterranean termites are widespread throughout the United States. Because they are so abundant, prevention alone may not always protect a structure from infestation. If a structure becomes infested, you must take additional action. Over the past few years, subterranean termite treatment has advanced rapidly. A decade ago we had only a few options from which to choose. However, many new products and techniques have been developed in the last five years. The following sections discuss the most widely used treatment options available to control subterranean termites. When planning a management strategy, consider all current registered options. ALWAYS READ THE LABEL BEFORE APPLYING A PESTICIDE FOR ANY PURPOSE.

Liquid Termiticides. Chemical barriers involve the application of a liquid insecticide around and underneath a structure, covering all areas where termites might gain access. As the name implies, the goal of a chemical barrier treatment is to put a complete barrier between the termites and the structure above.

If you are applying to	Apply this amount
Horizontal areas to be covered by concrete (slabs, attached entryways, garages, carports, porches and terraces)(Preconstruction only)	1 gal/10 sq. ft or 1 ½ gal./10 sq. ft. if soil is porous or fill is coarse gravel
Vertical critical areas (around sewer, plumbing or utility openings).	4 gal/10 linear ft/foot of depth
Other vertical areas (backfill against foundation walls; support piers; soil against inside foundation walls)	4 gal/10 linear ft/foot of depth to footing
Voids in foundation blocks (If preconstruction, can apply before capping.)	2 gal./10 linear feet

Table 10-2. Amount of termiticide to be applied to horizontal and vertical critical areas and hollow voids.

Two types of liquid termiticides can be found on the market today: repellent and nonrepellent. Repellent termiticides, such as pyrethroids, are faster-acting nerve poisons that are highly toxic to termites and repel termites from the treated zone. Often, the termites are able to detect the chemical before they get close enough to receive a lethal dose. Complete repellent barriers will effectively keep termites from entering the structure, are relatively inexpensive and will last for several years. However, putting down a perfect barrier under an existing house is very difficult. Construction features, plumbing lines and landscaping are just a few of the obstacles that make liquid barrier applications difficult, and termites may eventually locate a treatment gap and gain access into the structure.

Termites do not detect nonrepellent termiticides in the soil. Therefore, the termites tunnel into the barrier, contact the termiticide, may transfer the chemical to other termites and eventually die. Having a complete barrier is not as critical with a nonrepellent termiticide.

Heavy, clay-type soils are often found in Tennessee and may not hold the above described amount of diluted insecticide. Most manufacturers have amended their labels so the volume may be reduced, but there must be a corresponding increase in the concentration of insecticide so the same amount of active ingredient is applied to the same area of soil. The rates given above typically apply to the lowest concentration listed.

Preconstruction.The easiest time to apply a barrier is during construction. Treat the graded soil before the slabs are poured. Current regulations require a horizontal barrier (area to be covered by concrete), vertical barrier (vertical critical areas) and void treatment (Table 10-2). You must strictly follow the concentration and rate specified on the product label. It is illegal to use less than or greater than any rate or concentration specified on the label for preconstruction treatment. Table 10-2 lists the areas where termiticide should be applied pretreatment.

Pretreatment is an excellent time to apply labeled termiticides, such as borates, to the wood to create a barrier that will

stop the termites from entering the structure's wood. At this time, much of the wood to be treated is exposed and allows a more thorough treatment than post-construction. Using wood pressure-treated with borates may provide good distribution and penetration of the borates into the wood.

Impasse ™

Impasse ™ is a pyrethroid "locked-in" plastic used either as sheeting that is applied under concrete (Impasse Termite System) and/or is used around utility pipe penetrations (Impasse Termite Blocker) to prevent termites from entering the structure.

Newer environmentally-friendly technology not available everywhere in the U.S. just yet include:

Stainless steel mesh

Termi-Mesh is a stainless steel, wire mesh that is laid down as a barrier during the preconstruction phase or after construction to prevent termites from entering the structure. Pipes, posts, foundations and trenches are also fitted. Termites are too big to crawl through the spaces in the mesh, and the marine, grade steel is too hard for the termites to chew.

Particle-sized barriers

Particle-sized rocks of basalt or granite may provide a physical barrier to termites. The rock is ground into a specific size, which is too big for the termite's mandibles to move and too small to allow movement between the grains. It may be difficult to prevent tree root intrusion and other disruptions to these types of barriers.

Post Construction. Postconstruction treatment methods are considerably more complex and varied than preconstruction treatments. To achieve a complete termite barrier after construction, pest control operators may need to perform exterior soil treatments and interior soil treatments. These may include treatments of foundation voids, veneer, crawlspaces and basements. See Table 10-2 to determine areas that need to be treated postconstruction. Typically the horizontal area was treated in the pretreatment application. Baiting systems and wood barrier treatments are also a post-construction treatment method.

Exterior Treatment Methods. Treat the outside foundation soil after all grading is completed by digging a trench 6 inches wide and a minimum of 6 inches deep, but do not dig below the bottom of the footing. The trench should angle towards the foundation. Where the footing is less than 6 inches below the top of the grade, the trench should extend to the top of the footing. If the top of the footing is more than 12 inches below the surface, the soil must be trenched or trenched and rodded to a minimum of 4 feet, but not to exceed the footing.

If treatment of the exterior soil down to the top of the footing is not possible or practical, it will be necessary to indicate clearly to the customer that your treatment is either a "spot treatment" or "partial treatment."

See Figures 10-15 and 10-16 for treatment of exterior slabs, foundation voids, brick or stone veneer, vertical drilling of the inside perimeter of a slab, crawl space and basement treatments.

Calibration. Prior to applying termiticides, it is wise to calibrate your equipment. This is easily accomplished with a five-gallon bucket and a watch. Mark a one-gallon line in the bucket, and determine the time it takes to fill one gallon with treating tools and tips attached. Let's assume it took 30 seconds to fill a gallon or 1 minute to fill 2 gallons which resulted in an output of about 25 p.s.i. Assuming the structure to be treated has a one-foot footing and knowing that a treatment along an outside foundation requires 4 gallons per 10 linear feet, how long would it take to treat 10 ft?

30 seconds/1 gallons X 4 gallons = 120 seconds or 2 minutes.

Now figure the time you should be spending per foot.

120 seconds/10 feet=12 seconds/foot.

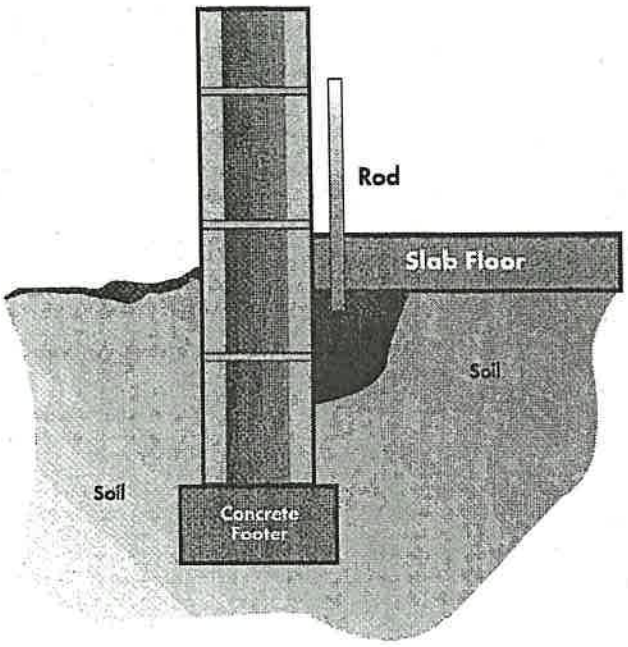
Another way to track your output is to use a flowmeter attached near the treating tool.

Some Potential Treatment Problems. Drill and treat brick and stone veneer only if they extend below grade level. Be sure to treat below the top of the foundation wall to prevent accidental contamination of the interior. If you identify a structure or an area as having the potential for a problem during treatment, it is advisable to station one person inside the structure while another performs exterior treatment of the soil, brick veneer, or block or rubble foundations. In some structures it will be necessary to drill, treat and plug one hole at a time to prevent contamination of the slab by the termiticide flowing out of unplugged drill holes. Other situations which require special treatment, but are not discussed in this manual include crawlspaces with plenums, inaccessible crawlspaces, slabs containing or covering heating ducts, wells, cisterns or springs within the foundation walls, proximity to water sources and others.

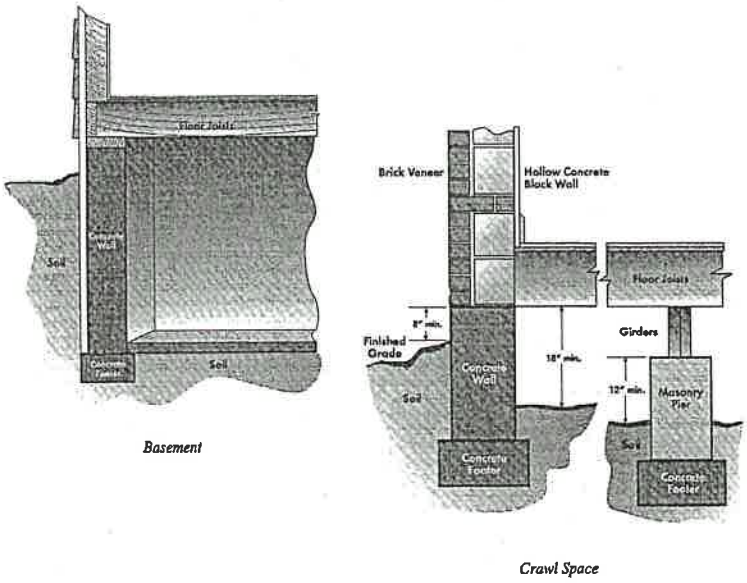
Rigid Foam Insulation Board. Building techniques that use foam insulation in direct contact with the soil can make termite protection by soil treatment virtually impossible. Termites do not eat the foam, but tunnel through the insulation to access wood in the structure. This allows them to avoid contact with soil treatment barriers. Termite infestations in foam insulation board often are not visible during an inspection. It is advisable to have the property owner remove outside foam up to 6 inches above and below grade level to allow for proper treatment and future inspection. For crawlspaces, remove the insulation from the inside foundations in the same manner.

Wood Treatments. When applied to wood in contact with the foundation or support piers, some borates can be used as a primary treatment or as another layer of protection. Several borate formulations containing disodium octaborate tetrahydrate (Bora-Care®, Shell-guard® and others) are available to treat unfinished wood. Bora-Care® or other similar products applied to wood where the termites may enter the structure (box sills, above piers, etc.) could deter termites from tunneling over these wood pieces into the structure. It may be more judicious to use wood treatment as a supplement to either a soil treatment or termite baiting system application.

Wood Injection. You can make direct injection of residual insecticides into termite galleries in the form of pressurized (aerosol) or liquid emulsions where termites are actively feeding in wood portions of the structure. The termiticide will bond with soil particles in the termite galleries just as they do in soil to provide some extended residual protection. Treatment with contact residual insecticides to wood surfaces will

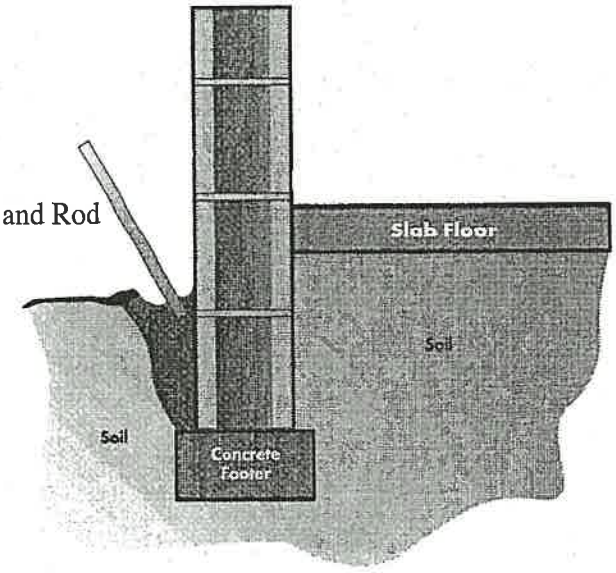


Vertical drilling.



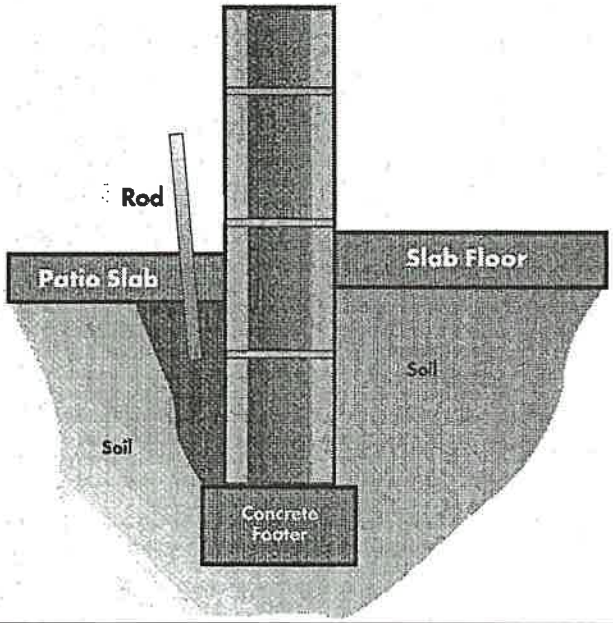
Basement and crawl space construction.

Trench and Rod

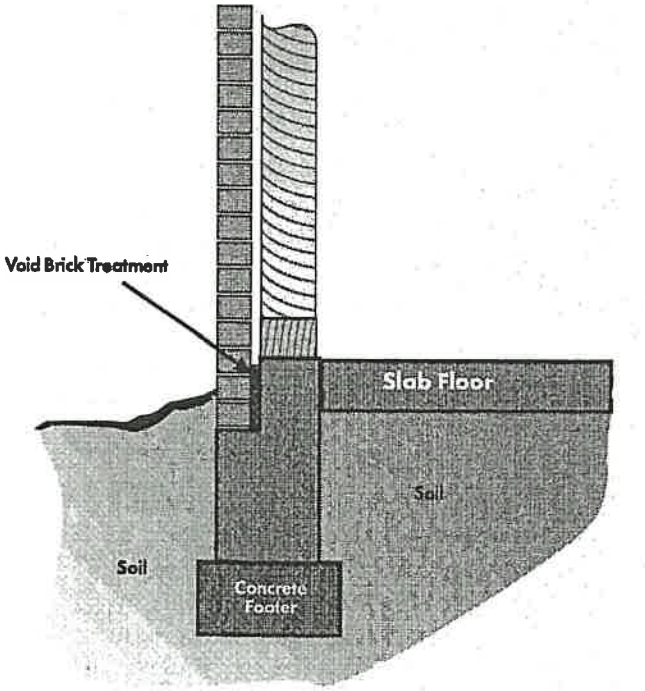


Exterior Soil Treatment.

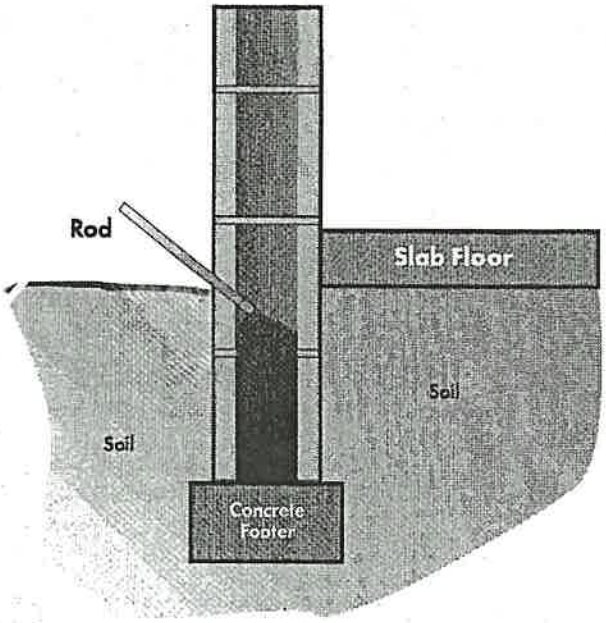
Figure 10-15. Exterior termite treatments.



Exterior Slab.



Treatment of brick or stone veneer.



Foundation Void Treatment.

Figure 10-16. Exterior termite treatments.

provide some short-term barrier effect, but will not provide extended protection, as does application of insecticide to the soil. It also may be possible to inject aerosol insecticides directly into wood on a limited basis by drilling and injecting into wooden structural components. However, it is difficult to achieve complete saturation of all the wood to prevent termite attack.

Special Tools and Techniques. In the past, sub-slab treatment relied only on the theory that termiticide applied at several points will move to rally and overlap. This would establish a continuous treatment barrier. However, uneven grade levels, grades sloping away from the foundation walls, or physical obstructions can result in failure to achieve these complete barriers under slabs. Tools and techniques such as termiticide foam and directional or lateral dispersion have been developed to enhance our ability to achieve a thorough chemical barrier.

Soil Retreatments. You should never make routine or annual retreatments. The label does not allow routine or annual retreatments and the label is the law. Make retreatments only if there is evidence of reinfestation, if the initial treatment was inadequate or if moving soil around the structure has broken the chemical barrier. The retreatment is normally a partial treatment in the areas of infestation or soil disturbance. Record the retreatment as a partial or spot treatment on the statement of services.

Subterranean Termite Baits

Termite baiting takes a different approach to subterranean termite control than the chemical barrier technique. Instead of protecting a structure by creating a barrier between it and the termites, baiting attempts to suppress or kill the termite colony in the soil. Commercial termite baits are a relatively new technology. The most widely used baits are applied below ground. The following information describes, in general, a standard application process.

First, insert bait stations into the ground around the outside of the structure approximately at regular intervals (about 10 - 15 feet, varies by manufacturer) and/or at conducive conditions. Inside the bait stations are untreated pieces of wood called 'monitors." Inspect the monitors for termite activity on a regular basis, according to the label. If live termites are found in the monitors, replace the monitors with the toxic bait or add bait to the station. The idea is to get the termites that are already foraging on the wood monitor to pick up the bait. Certain bait products can be used by themselves. Others can be used in combination with a spot chemical treatment or a complete barrier.

Because the below ground bait stations are placed outside the structure, they do not directly affect termites that are already foraging inside. It may take over a year for termites to find the outside stations. To address inside infestations, certain commercially available baits also come in above ground stations. In general, these stations are plastic boxes that contain a paper matrix laced with termiticide. To use the boxes, attach them over a termite mud tube or directly onto infested wood. The termites forage inside the box and consume the paper bait.

Professional Termite Baiting Systems

Advantages

- Baits are environmentally friendly. They place much less active ingredient into the environment than liquid insecticides used in barrier treatments.
- Termite baits are ideal for use around structures inhabited by people with chemical sensitivities. When an infested structure is within 50 feet of a well or 100 feet of a body of water, termite baits may be the only treatment option.
- Use baits when barrier treatments have failed to provide satisfactory control.

Disadvantages

- There is no way to lure termites into the monitoring stations. It may take months or even more than a year before baiting can begin.
- Professional baiting systems are generally more expensive than barrier treatments due to monitoring costs.
- When used alone, termite-baiting systems do not protect the structure directly. Termites feeding within the structure may continue to do so until the colony is eliminated or they are controlled with an above ground station.

It is absolutely necessary that monitoring continue after control has been achieved with a baiting system. Unless a soil termiticide has been also applied, there is no residual in place.

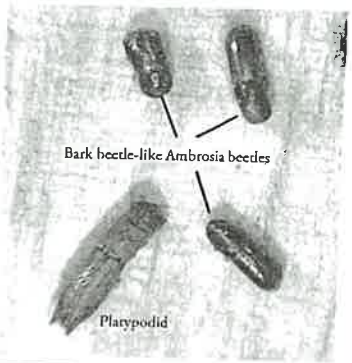
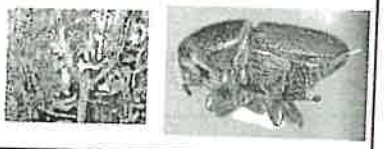
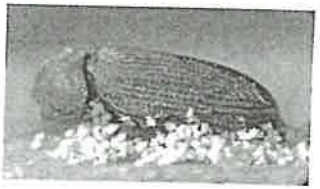
Other Wood-Destroying Insects

By using the anagram ALBOW it is easy to recall which beetles infest seasoned wood: A= anobiid powderpost beetle; L= lyctid powderpost beetle; B= bostrichid powderpost beetle; O= old house borer; and W= wharf borer or weevils. Wharf borers and weevils are of little significance in Tennessee and are not discussed further.

Insects That Can Reinfest Structural Woods

Powderpost Beetles. There are three families of powderpost beetles and all of these may reinfest seasoned wood. The most common are the lyctid and anobiid powderpost beetles. The bostrichids are the least common family. Small, "shot hole" exit openings in the wood surfaces are sometimes an indication of a powderpost beetle infestation. See Table 10-3 for descriptions and more information on these insects.

Old House Borers. The old house borer, which is a member of the longhorned beetle family, attacks only sapwood of pine and other softwoods. This species is unusual in that it will reinfest structural wood, unlike other common members of its family. In Tennessee it has been particularly troublesome in its attacks on new pine log homes, and it is sometimes destructive to sheeting, siding or porch flooring that has been exposed to high humidity, water leaks or blowing rains. Indoor infestations are infrequently encountered in this state, but old house borers are occasionally built into new structures and can remain active for many years, even under conditions of low ambient humidity. Reinfestation, however, is unlikely under these conditions. (See Table 10-3 for descriptions and more information on this pest.)

*AGE and Type of Wood Attacked	Appearance of Frass in Tunnels	Reinfest seasoned wood	Insect Type	Identification characters	Comments
JEW; dead or veakened trees or nseasoned logs f hardwoods and oftwoods	Galleries are free of boring dust; Spores of fungi (ambrosia) are carried into the galleries by attacking adults. Larvae feeding on the fungi. Fungi stain the wood bluish-black.	No	Ambrosia beetles 	**Adult:** cylindrical and their antennae are elbowed and terminate in an expanded club. The platypodid ambrosia beetles are much elongated, and their antennae are elbowed and terminate in a much expanded, flattened, one-segmented club.	Cause alarm when adults emerge from firewood dwell thin homes and collect on windowsills or in light fixtures. No control needed because they are not reinfesting. Use a vacuum to collect adults.
LD; Ring rous hardwood: k, hickory, ash, lnut, pecan d many tropical dwoods	Fine, flour-like, loosely packed	Yes, lyctids rarely infest wood older than 10 years (starch greater then 3 percent preferred) usually limited to hardwood paneling, trim, furniture, and flooring.	Lyctid beetles 	**Adult:** 1/8 to 1/4 inch in length; reddish-brown to black. Head protrudes forward and is visible from above; antennae have a 2-segrnented club. **Larvae:** Breathing pore closest to the end of the body distinctly larger than the other larval breathing pores.	In nearly all cases, infestations were from wood that contained eggs or larvae at the time it was used in the home. General infestation of a building is unlikely, and timely replacement and disposal of materials (e.g., pieces of trim or furniture) obviously infested by lyctids often will eliminate an infestation altogether.
W; Bark/sapod interface nany kinds of dwood and wood trees.	Fine to coarse, bark colored, tightly packed	No	Bark beetles 	**Adult:** cylindrical and their antennae are elbowed and terminate in an expanded compact club.	Cause alarm when adults emerge from firewood with in homes and collect on windowsills or in light fixtures. No control needed because they are not reinfesting. Use a vacuum to collect adults.
W and OLD; wood & wood	Fine powder with pellets, loosely packed; pellets may be absent and frass tightly packed in some hardwoods	Yes, often occur in basements, crawlspaces barns and other unheated structures where moisture content of the wood is high. They can infest and remain active in wood that has been n service for decades.	Anobiid beetles 	**Adult:** 1/8 to 1/4 inch in length and are reddish-brown to nearly black; hood like pronotum conceals the head when viewed from above and wing covers are finely grooved.	Control can be achieved by both chemical and nonchemical methods. Usually central heat and air reduces wood moisture so the air is insufficient moisture content to support extensive infestations in living and attic areas. If favorable conditions of moisture and temperature exist, infestations can spread vertically into walls and upper levels of a structure. Sources of an old infested lumber, beetles flying in from outdoors, or firewood. Powder post beetles are slow growers that can reinfest every year.

Round 3/32 - 9/32	NEW; Softwood & hardwood (bamboo)	Fine to coarse powder, tightly packed	Rarely, native Tenn. species do not reinfest, exotic species may; bamboo borer commonly damages bamboo products, especially baskets brought to Tenn. from the Orient	Bostrichid beetles 	**Adult:** The bamboo borer, *Dinoderus minutus*, is a dark brown beetle; head hidden from above, bumps on pronotum.	Bostrichids rarely cause significant damage in framing lumber and primarily affect individual pieces of hardwood flooring or trim. Replacement of structurally weakened members is usually the most economical and effective control method.
Oval 1/4 - 3/8	NEW and OLD; Softwood	Very fine powder & pellets, tightly packed; wood surface of galleries appears to have a wavy or rippled texture	Yes	Old house borer 	**Adult:** 3/4 inch long, dark brown to black bodies, raised area on each side of the pronotum and indistinct gray cross bands on the wing covers. **Larvae:** 3 eye spots to left and right of mandibles; as larva grows, their chewing can be heard as a ticking or rasping sound	Larval development usually takes three to six years, it may be as short as two years or as long as 10 years or more depending on environmental conditions. Moisture content of 15 to 25 percent and protein content of 0.2 percent are considered ideal conditions for larval development. Old house borers are often found in houses that are less than 10 years old; hence their name is a misnomer.
Round-oval 1/8 - 3/8	NEW; Softwood & hardwood	Coarse to fibrous, mostly absent	No	Other round-headed borers or long-horned beetles  	**Adult:** range from 1/2 to 3 inches long and have long, thin antennae that may be longer than the body. They usually lay eggs on unseasoned, rough-sawed timbers or logs. The larvae, called round-headed borers, feed in the wood. They bore large galleries as they move through wood and oval-shaped exit holes when they emerge as adults. **Larvae:** Elongate, light-colored, soft-bodied, "worm-like" insect with a dark brown head. The area of the body immediately behind the head is only slightly broader than the rest of the body. Full-grown larvae of many common species exceed 1 inch in length.	Damage caused by round-headed borers is encountered occasionally in almost all types of wood products. Some members of these two highly variable families of borers spend their entire larval lives under bark of trees, and thus they never become associated with wood products. Others feed deeply into the wood of hardwoods or softwoods, after spending a period of time under the bark. None of these insects, with rare exception (notably the old house borer), will re-infest seasoned wood. Some species will, however, remain in air-dried lumber for up to several years before emerging as adults. In such cases, sounds produced by the feeding of borers in structural wood can be a source of concern and annoyance. These insects also can cause significant disfigurement to siding, paneling and drywalls in the process of their emergence. Emergence of wood borer adults from firewood is also a very common occurrence indoors.
Oval 1/8 - 1/2	NEW; Softwood & hardwood	Sawdust-like, tightly packed	No	Metallic wood borer  Flat-headed borer 	Adult: called a metallic wood borer, is spindle-shaped and somewhat blunt at the head end. The body often has a shiny metallic appearance, and the antennae are not conspicuous. **Larvae:** similar to that of a round-headed borer except that the area of the body immediately behind the head is usually abruptly much broader than the rest of the body.	

Table 10-3. Wood-infesting beetles. *NEW wood is defined as standing or freshly felled trees and unseasoned lumber. *OLD wood is seasoned or dried lumber. Softwoods are also known as conifers and typically have needlelike leaves, are evergreen and are columnar in form. Pine, hemlock, cedar, and redwood are common softwoods. Hardwoods typically have broad leaves, shed all leaves at once and are broad-formed having a spreading crown. Oak, ash, hickory, and yellow-poplar are common hardwoods. The heartwood is the darker center of the tree composed of cells that are no longer living, but provide mechanical support to the tree. The sapwood is located close to the bark of the tree and is a lighter colored tissue that transports water and nutrients in a living tree. *All images Courtesy of UT E&PP.*

Powderpost and Old House Borer Control

Many wood-boring beetle problems are introduced into homes in lumber or finished wood products such as furniture, paneling and flooring. Wood-boring beetles will not infest wood that is painted, varnished, waxed or similarly treated. Any beetles present most likely infested the wood articles before they were finished. However, they may lay eggs in exit holes left by a previous generation or into open pores of cut ends of finished wood. Nevertheless, wood-boring beetles present a threat to unfinished wood.

Active or not? It is important to determine if infestations are active, because powderpost beetle populations can die of natural causes, and if this is the case, control measures would not be necessary. There are several ways to determine if an infestation is active or not. One way is to mark or seal existing holes, sweep or vacuum all powder, and recheck the wood for new holes at a later date. It may be best to wait until spring or early summer to inspect for fresh frass or new holes. Powderpost beetles damage wood slowly, so homeowners should not feel the urgency to act immediately to ensure the structural integrity of their home.

Prevention

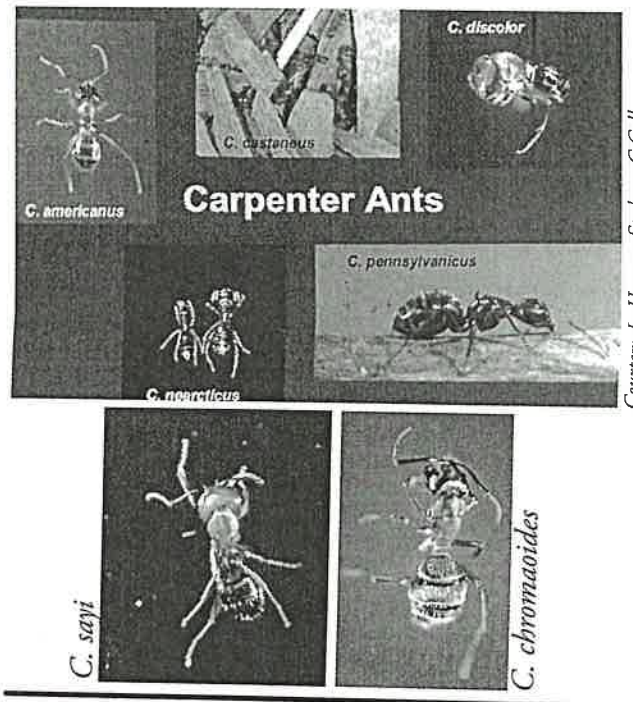
Many powderpost beetle infestations occur when people use old lumber from a barn or woodpile to panel a room or add onto a structure. Lumber that has been improperly dried or stored should not be used, especially if exit holes are present. Females lay eggs only on unfinished surfaces; therefore, if wood is painted, varnished, waxed or otherwise sealed it is often safe from attack as long as no exposed edges are present. Unfinished wood can be protected by painting or other finishing practices. Beetles emerging from painted wood were present in the wood prior to painting. Beetles can reinfest painted surfaces by laying eggs in previous emergence holes. Seal exit holes to prevent this from happening.

Alternative controls — temperature modification

Small items, such as picture frames, can be heated at 120 to 140 degrees F for six hours to kill existing life stages. Freezing (0 degrees F) infested wood for 72 hours will also kill all life stages.

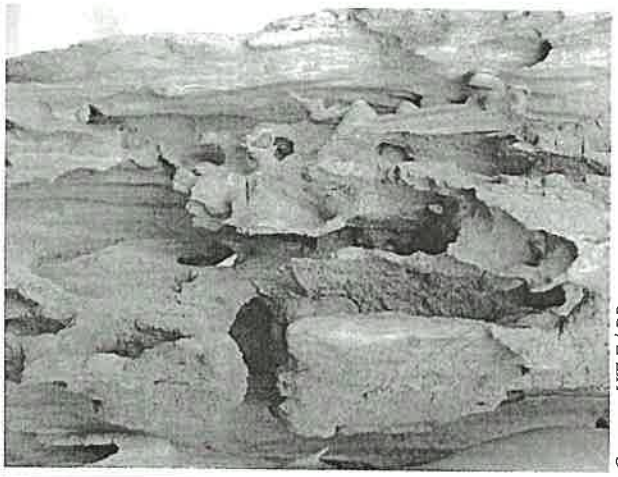
Moisture control

If wood moisture can be kept below 14 percent during spring and summer, these conditions would be unsuitable to anobiid development or reinfestation. Moisture barriers can be used in damp crawl spaces. Polyethylene sheeting can be used to cover 70-80 percent of the soil in the crawl space. Leave a 12-inch bare soil zone next to the foundation. Moisture rising



Courtesy, L. Hansen, Spokane C.Coll.

Figure 10-17. Several common species of carpenter ants found in Tennessee. The smaller carpenter ant species, *C. nearticus*, *C. sayi* and *C. discolor*, are more likely to nest in a curtain rod or cause limited damage to a structure and should be classified as a nuisance pest rather than a wood-destroying organism.



Courtesy, UT E&PP

Figure 10-18. Carpenter ant nests consist of interconnecting, irregular galleries that are kept free of debris.

Courtesy, UT E&PP

Figure 10-19. Debris, including coarse boring dust and uneaten insect parts that have been removed from the carpenter ant galleries, is usually evident outside the nest.

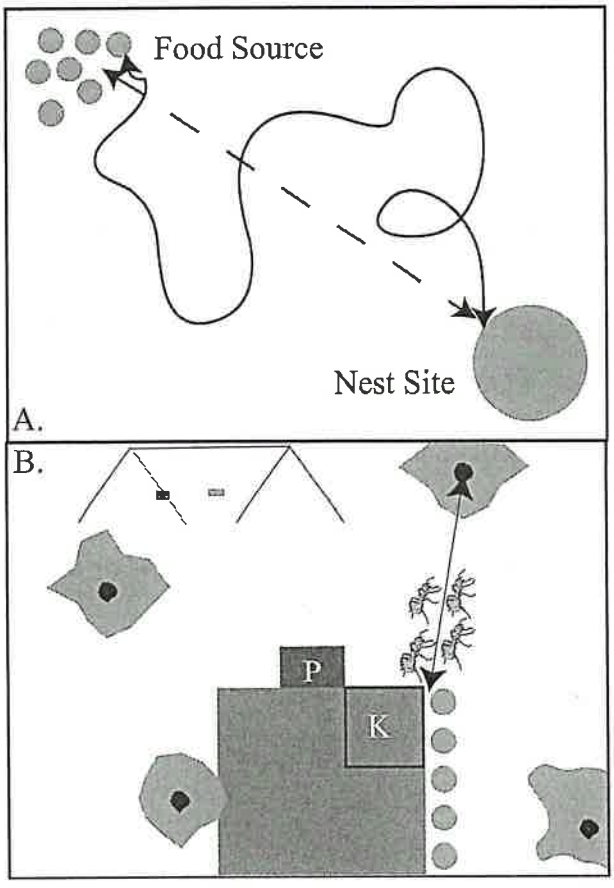
from the soil around the perimeter will be exhausted through the foundation vents. Most building standards recommend 1 square foot of vent opening per 150 square feet of crawl space soil area. Professionals should use a moisture meter to indicate the moisture content of the wood and therefore the possible susceptibility to powderpost beetles.

Wood replacement

Boards, sheets of paneling, etc., may be replaced if all evidence indicates the infestation is localized. If new holes are found in adjacent areas, other action is needed.

Borates

Some formulations containing borates have the potential to penetrate and kill larvae in the wood, as well as those beetles entering or exiting the wood surface. Topical treatment must be made to unfinished surfaces; borates will not penetrate paint or varnish, but can penetrate a water-repellent stain if the water-repellency is broken. Pressure washing prior to borate application may break down the water-repellent seal. Joists, sills, rafters, subflooring, studs, decking and siding are excellent candidates for the borate treatment. If hardwood floors are infested, the finish must be removed (sanded) prior to borate application.



Courtesy, Modified from J. Klotz, UC Riverside

Figure 10-20. Ants will randomly forage, but upon locating a food source, they usually return to the nest, in a straight line (A). Place attractant where ants have been seen foraging and visualize a straight line as they return to the nest (B).

Other residual insecticides

Several insecticides are labeled for treatment of beetle-infested wood. In general, spraying or brushing these products onto wood surfaces coats the surface and may penetrate slightly. Adult powderpost beetles will be killed as they exit the treated wood, as will larvae attempting to bore into the wood. Wall voids can also be foamed, but avoid foaming near electrical sources.

Fumigation

Insecticides that are painted or sprayed onto surfaces can be used only if the infested wood is accessible for treatment. If infestations have spread into walls or between floors and foaming is not feasible because of electrical sources, fumigation may be needed. Fumigation is costly and should only be considered as a last resort. Early detection can prevent the need for fumigation and allow the use of other methods to control these pests as mentioned above.

If only furniture, antiques and other smaller articles are infested, they can be fumigated at a lower cost than fumigating an entire building. This can often be done within a sealed tent, tarp, trailer or vault to maintain gas concentrations at high levels. A pest control operator licensed to fumigate is needed for this operation.

Insects that Utilize Structural Wood for Nesting Sites

Carpenter Ants (Camponotus spp.). Carpenter ants are widely distributed throughout the United States. They are one of the largest of our common ants. We have about 10 species of carpenter ants (Figure 10-17) in Tennessee, which may be black, reddish-orange, golden or reddish-orange and black. The most commonly observed carpenter ant is *Camponotus pennsylvanicus* or the black carpenter ant, which is dark brown to black (Figure 10-17), and 1/4 to 1/2 inch. Queens may be 3/4 inch or more long.

Carpenter ants, like carpenter bees, do not eat wood; they use wood for nesting. Carpenter ant nesting in itself is not likely to cause extensive structural damage. Presence of carpenter ants, however, might indicate existence of a more serious problem, because these insects are attracted to moist or decayed wood. They are frequently found in structural hardwood or softwood that has become wet due to a water leak or poor drainage and ventilation. However, carpenter ants may later move into sound, dry lumber. They will even nest in existing cavities without causing any structural damage. In structures, they often nest in porch columns, roofs, window-sills, hollow-core doors, wood scraps in dirt-filled porches, and wood in contact with soil. Their nests are occasionally associated with window sills and surrounding timbers where blowing rains have provided the moisture necessary for softening and decay. Frequently, carpenter ant infestations are more of a carpentry problem than a pest control problem.

Carpenter ants feed on honeydew excreted by aphids, on other insects, animal remains and household food scraps. Carpenter ants excavate galleries in the wood to rear their young. Carpenter ants eject the chewed wood from their mouths in the form of coarse sawdust. Their nests consist of interconnecting, irregular galleries (Figure10-18) that are kept free of debris. The gallery walls are smooth, as though

they had been sanded with fine-grit sandpaper. In addition to the adults, clusters of white eggs, larvae and pupae will be present in active colonies. Outside the nest, debris that has been removed from the galleries, including coarse boring dust and uneaten insect parts (Figure 10-19) is usually evident. The unique makeup of debris that collects beneath ant-infested wood can be the first clue to the identity of the insects living in the wood. Materials expelled from galleries of other types of wood-destroying insects consist only of boring dust, sometimes mixed with fecal pellets.

The key to the control of carpenter ants is locating their nest(s). Unfortunately, this is often difficult, since the nests are usually well hidden. However, if you can locate them there is an excellent chance of controlling the ants. Eliminating a nest outdoors may be just as important as eliminating one inside the building. In some cases, an entire colony may migrate from one nesting site to another, such as from a tree outdoors to structural timber indoors.

As an aid to finding indoor carpenter ant nests, examine these suggested locations:

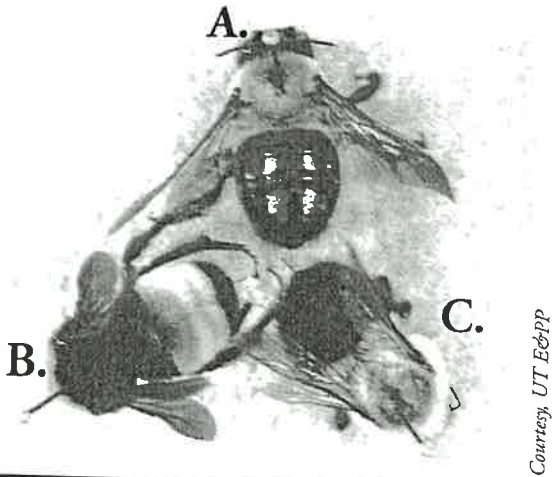
- wood affected by water seepage (porch floors, posts, columns and roofs),
- wood in contact with soil,
- wood adjacent to dirt-filled slab porches, and
- hollow doors, curtain rods, appliances and electrical equipment.

Some signs to look for when inspecting for a carpenter ant nest indoors are:

- piles of coarse sawdust containing ant body parts on the floor or foundation,
- sounds of crinkled cellophane produced by alarmed workers in wall(s) and
- ant activity — they frequently forage for food in kitchens. However, even when the nest is in a building, you may see only a few ants. This is because the ants are active at night and often forage outside.

Some locations to investigate outdoors are:

- firewood piled in garages or next to a house,
- stumps, logs and trees that might contain nests, and
- trees with branches hanging over and touching the roof of a house. Ants may travel over these branches, and electric and phone lines into the building.



Courtesy, UT Ed-PP

Figure 10-21. Carpenter bees (A) resemble large bumble bees (B,C), except that the abdomen of bumble bees has a dense covering of yellow or black hairs.

Using Attractants to Locate the Nest

The general vicinity of a carpenter ant nest can often be located by placing an attractant such as a small dab of honey, maple or corn syrup alone or mixed with crickets or mealworms in the area(s) where ants have been seen. Carpenter ants feed more on proteins (crickets or mealworms) in the spring and more on carbohydrates in the fall (honeys and syrups). (Cleanup is aided by placing this attractant onto small squares of wax paper, index cards, or the back [non-sticky side] of pieces of masking tape). The best time to do this is late at night, because this is when carpenter ants are most active. After the ants have fed on the attractant, follow them on their journey back to their nest. Foragers usually return to the nest in a straight line (Figure 10-20). A red lens on a flashlight may allow observation of the ants without disturbing them.

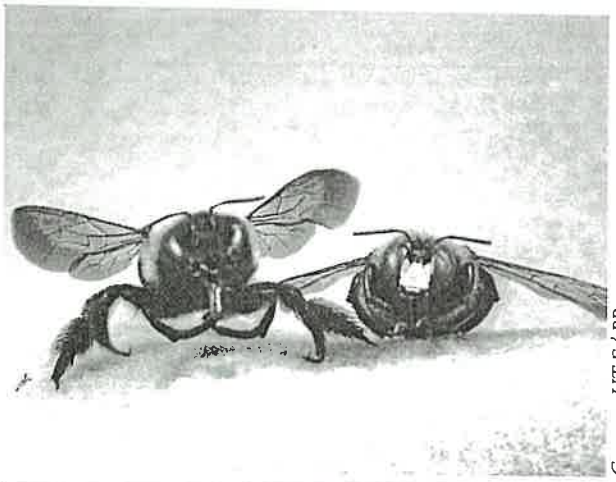

Courtesy, UT Ed-PP

Figure 10-22. Carpenter bees are solitary. The female's face is entirely black; the male's has a conspicuous yellow block. In both sexes, the top of the abdomen is shiny-black and almost bare.

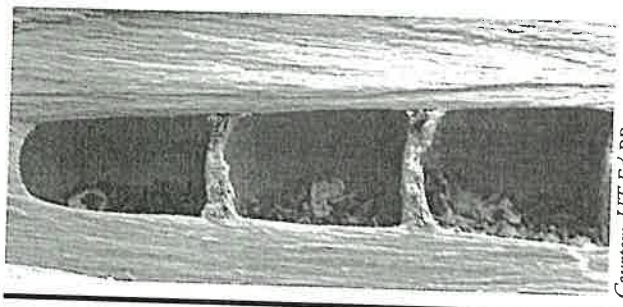

Courtesy, UT Ed-PP

Figure 10-23. Each longitudinal gallery consists of a series of cells. Each of these will be provisioned with "bee bread," which is a mixture of pollen and nectar collected by the female. One egg is laid in each cell and the cell sealed.

Carpenter ants seen in the home may actually be nesting outdoors and foraging indoors for food and water. Once an outdoor nest is discovered, it can be baited, sprayed, drenched, dusted or foamed with an insecticide labeled for that site.

If the nest is located indoors, there are several options: baiting, dusting pipe and other wall penetrations, and direct treatment of the nest. Carpenter ant baits should not be placed as in a cockroach bait application, but only to areas where carpenter ants are foraging or where their activity has been noted. Residual insecticides labeled for carpenter ants may also be used. However, baits are preferred for indoor treatments because of their low toxicity and reduced exposure risk.

If a nest is located indoors, but ants continue to forage outdoors, a perimeter treatment with a slow-acting nonrepellent insecticide, such as fipronil, may also provide control. The carpenter ants cross the treated zone and do not detect the nonrepellent insecticide. The ants die slowly and may contaminate nest mates. This technique has been very successful in the northwestern U.S.

Carpenter Bees. Carpenter bees resemble large bumble bees except that the abdomen of bumble bees has a dense covering of hairs (Figure 10-21). In the spring, carpenter bees become a nuisance as they fly erratically, close to homes and other buildings. Males (Figure 10-22) hover like hummingbirds, waiting for females to emerge so they can mate. If the males are disturbed, they may hover or buzz around the head of a person. Only the females sting if you provoke them. After the mating season, carpenter bees spend most of the summer loitering around the nest or nearby flowers.

Aside from the nuisance of having carpenter bees around, they also bore into seasoned woods, especially softwoods such as cedar, redwood, pine and fir. Bees may damage soft or weathered wood on porches, decks, shed ceilings, railings, overhead trim, porch furniture, dead tree limbs, fence posts, wooden shingles, wood siding, window sills and wood doors.

In the spring, female bees bore brood chambers into the wood where they will lay their eggs and the young will develop. The bee begins the chamber by boring a large circular hole, about ½ inch wide, into the wood. After boring against the grain, they turn sharply and bore along the wood grain for 4 to 6 inches. Boring dust collecting beneath the circular entrance to the gallery is sometimes the first evidence of the bee's activities.

The female provides her tunnel-nest with "bee bread" (a mixture of pollen and regurgitated nectar), which serves as food for the larvae when the eggs hatch. She makes a cell for each larva and closes each cell with chewed wood pulp. There may be as many as six to eight cells in the tunnel or gallery (Figure 10-23). The time required to complete development from egg to adult varies from one to three months. Newly formed adult bees usually emerge in late August. These bees overwinter in galleries and will mate the following spring and start the cycle over.

Structural damage caused by one or two carpenter bees is slight. However, later broods may reuse and lengthen old tunnels. The activities of numerous bees over a period of years will cause structural damage.

Carpenter bees rarely attack painted wood. Therefore, keeping all exposed wood surfaces painted is a good preventative measure. Wood stains will not prevent carpenter bee damage.

Treat carpenter bee brood chambers with insecticidal dusts, wettable powders, microencapsulations or residual aerosol formulations. Apply the insecticide to the tunnel entrance in the evening when the bee is less active. Do not plug the hole just yet. The adult bee must be able to pass freely over the insecticide-treated surface. After a day or two the adult bee will die. The hole is then sealed with a wooden dowel coated with suitable sealants, such as carpenter's glue or wood putty, to prevent reinfestation, moisture intrusion and wood decay.

Review Questions

1. A pre-construction soil application of termiticide to an area that will be covered by a concrete slab, such as a basement or garage floor, is called a _____.
   A. horizontal barrier
   B. vertical barrier
   C. sand barrier
   D. concrete barrier

2. A chemical barrier established around the base of foundations, plumbing or the back-filled soil against foundation walls is called a _____.
   A. horizontal barrier
   B. vertical barrier
   C. sand barrier
   D. concrete barrier

3. A small basement home needs a postconstruction termite treatment. Assume pipes and other conduit enter through the foundation walls and no penetrations or cracks are found in the slab. There are 4 feet of soil from grade level to the top of the footing on the exterior foundation wall. The foundation is constructed of masonry block. How many gallons of diluted insecticide are needed to provide a continuous barrier to termites if the structure has an outside and inside perimeter of 5 feet x 10 feet?
   A. 300 gallons
   B. 66 gallons
   C. 132 gallons
   D. 30 gallons

4. An adult lyctid powderpost beetle can be distinguished from other powderpost beetles by its:
   A. head visible from above and a 2-segmented antennal club.
   B. head not visible from above and a 3-segmented antennal club.
   C. head not visible from above and bumps on pronotum.
   D. head visible from above, bumps on pronotum and a 3-segmented antennal club.

5. Anobiid powderpost beetle adults are distinguished from lyctid powderpost beetles by
   A. rough bumps on the pronotum
   B. a flattened body shape
   C. a hoodlike pronotum that conceals the head
   D. concave wing covers

6. Severe wood decay occurs only in wood with a moisture content greater than _____ percent.
   A. 5
   B. 10
   C. 15
   D. 20

7. Old house borers produce a(an):
   A. round 3/8 - ˚ inch emergence hole
   B. "d"-shaped emergence hole
   C. round, 1/3 inch emergence hole
   D. oval, 1/4 inch emergence hole

8. Bark beetles cannot reinfest seasoned wood. Which of the following does not describe bark beetle damage?
   A. larval tunnels are free of frass
   B. hardwoods and softwoods are attacked
   C. eggs are laid in the growing cells between the bark and the wood
   D. wood is slightly etched from larval tunnels

9. Carpenter bees can be distinguished from bumble bees by the carpenter's
   A. hairy top of abdomen
   B. pollen basket on the leg
   C. bare top of abdomen
   D. lack of yellow on the abdomen

10. Adult termites can be distinguished from adult winged ants by the termite's:
   A. straight antennae, broad waist and equal-sized wings
   B. elbowed antennae, broad waist and equal-sized wings
   C. straight antennae, pinched waist and equal-sized wings
   D. elbowed antennae, pinched waist and unequal-sized wings

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

Chapter 11 Special Accounts

It is often the choice of pesticide and the placement of these selected pesticides that is so important with sensitive environments or special accounts.

Commercial Food Establishments

Examples of commercial food handling establishments include restaurants, food warehouses, and food processing plants. Specific government regulations are in place to protect food safety in these places of business. Before you use any pesticide in a food handling establishment, make sure you understand all these rules. If something is confusing, check with your supervisor, Tennessee Department of Agriculture inspector, or other appropriate officials.

Food handling establishment: facility where food is served, prepared, processed or held. This definition does not include a private residence.

Food area: area where food is received, stored, packed, prepared or served.

1. Probably the most beneficial advice to anyone using pesticides in food handling establishments is to ensure the pesticide planned for use is labeled for food handling establishments and for the intended area within this facility.
2. Read the label directions very carefully before using.
3. Mix any pesticide before going into the food establishment.
4. USDA food inspected plants have strict requirements for the use of residual pesticides. A few are listed below:
   - Do not apply pesticides during production hours.
   - Tamper-resistant stations must be used for dry rodent baits.
   - Distinctly color any powdered or granular insecticides to aid distinction from food substances.
   - Liquid and dry baits with a food base of meal or flour should also be colored. If the food base is pressed into cakes or pellets, than color does not need to be added.
   - Do not use pesticide tracking powders.
   - Even non-pesticide tracking powders (for monitoring) should be colored.
   - Ventilate treatment sites and wash facilities and equipment after pesticides are applied.
   - The USDA Food Safety and Inspection Service no longer provides or updates a book of approved proprietary substances.
5. Do not contaminate food or food surfaces by directly spraying or causing drift to these sites.
6. To decrease the chances of drift, use baits, crack and crevice treatments or void injections.
7. Do not apply baits, dusts or sprays to voids above food surfaces.
8. Carefully record any pesticides used and the details of the application.

Hospitals and Nursing Homes

If you think about it, hospitals and other health care facilities act like a small community. Housed within these facilities you'll find lodging, garbage disposal, drug dispensaries, storage areas, and often all-day food service, not to mention the movement of people in and out of the facility. People in this facility are often more susceptible to pesticides because of their age, physical condition or medication. With this type of environment we must carefully balance the risk of pesticide exposure with the health risk of the pests. Hospitals sites (medical labs, sterile rooms, operating rooms or high technical equipment) often require sterile environments and little or no pesticide use. Sanitation and exclusion practices should be the first step in controlling pests in patients rooms. Here are a few guidelines to use when applying pesticides in patient areas:

- Patients should not be present when pesticides are applied.
- Get permission in writing from a staff member before applying a pesticide when a patient cannot be moved.
- Pesticides should only be used when necessary.
- Make sure the pesticide is labeled for use in the type of health care facility being serviced.
- Put an emphasis on baits and similar products.
- It is wise to use low odor products.
- If liquids or dusts are used, they should be applied to cracks or voids.
- If uncertain about a procedure or product, consult your supervisor.

Electronic Equipment

Because of the sensitivity and susceptibility to damage of some electrical equipment by pesticides, it is wise to limit the use of pesticides in these environments. Electronic equipment often requiring special care include computers, airplanes, technical equipment often found in laboratories, and other similar types. Here is a set of guidelines for servicing these accounts:

- Do not apply a pesticide inside electrical equipment unless your supervisor agrees.
- Use mechanical control device such as vacuums, glue boards, sticky tapes, traps and only when necessary.

- Baits are preferred over sprays and dusts.
- Often it is best to have the client disassemble, clean and vacuum an infested piece of equipment.
- The solvents in some pesticide may become airborne. Do not use these pesticides near electronic equipment.
- Eliminate any type of drift near this equipment. Do not use dust or tracking powder.
- Always consult your supervisor if you are unsure about a treatment.

Schools and Day-care Establishments

Because young children crawl on floors and often place items in their mouths, they are more likely to be exposed to pesticides. When managing pests in schools and day-care centers, follow the guidelines in PB1603 Suggested Guidelines for Managing Pests in Tennessee's Schools: Adopting Integrated Pest Management available from your Extension agent or at http://www.utextension.utk.edu/, which should be included in your category 7 study materials. See our UT Web sites (http://eppserver.ag.utk.edu/sch_ipm.htm or http://utyeah.utk.edu) for more information on school IPM in Tennessee The University of Florida has a national Web site devoted to school IPM (http://schoolipm.ifas.ufl.edu/).

Below is a shortened list of guidelines:

- Use sanitation and exclusion practices to remove the pests' access to food, water and shelter.
- Applied pesticides on an "as needed" basis as determined by inspection, monitoring, or pest sightings.
- Pesticides should not be applied when occupants are present and a waiting period should be established between pesticide application and re-occupation of treated areas.
- 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.
- Rodenticide use is discouraged. Should their use be deemed necessary, they should be placed in anchored, tamper-resistant stations. Place packs should never be used in this environment.
- Rodent traps should be hidden from view.
- "Fogging" or use of space sprays is discouraged.
- Enter pesticides used and pests sighted into the appropriate log books.

Appendix A Resources

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- Wood-Destroying Organisms Licensing Manual. PB 1703.
  http://eppserver.ag.utk.edu/pat/PATinfo/training/Manuals.htm
- Subterranean Termite Control. PB 1344.
  http://www.utextension.utk.edu/publications/pests/default.asp
- Carpenter Ants: Those Big Ants in Your Kitchen and Bathroom. PB1599.
  http://www.utextension.utk.edu/publications/pests/default.asp
- Managing Pests Around the Home. PB1303.
  http://www.utextension.utk.edu/publications/pests/default.asp
- Managing Structure-Invading Ants. PB 1629
  http://www.utextension.utk.edu/publications/pests/default.asp
- Wood Use Around the Home
  http://web.utk.edu/~tfpc/extens/ex-home.htm
- Selection and Use of Preservative Treated Wood
  http://web.utk.edu/~tfpc/publicat/treat.htm
- Decay Resistance of Wood
  http://web.utk.edu/~tfpc/publicat/decay.htm

Other University of Tennessee Extension Publications pertaining to Category 7

- General Rodent and Pest Control Licensing Manual. PB1673.
  http://eppserver.ag.utk.edu/pat/PATinfo/training/Manuals.htm
- Public Health Pest Control: Tennessee Mosquito Control Handbook Licensing Manual. PB1685
  http://eppserver.ag.utk.edu/pat/PATinfo/training/Manuals.htm
- Category 8 Public Health Pest Control Certification Manual.
  http://eppserver.ag.utk.edu/pat/PATinfo/training/Manuals.htm
- Commodity and Structural Fumigation Licensing Manual.
  http://eppserver.ag.utk.edu/pat/PATinfo/training/Manuals.htm
- Bird Control in Tennessee
  http://eppserver.ag.utk.edu/pat/PATinfo/training/Manuals.htm
- Common Ticks of Tennessee and Their Control. PB726.
  http://www.utextension.utk.edu/publications/pests/default.asp
- Control Cockroaches in the Home. PB 1024.
- The Brown Recluse Spider.PB 1191
  http://www.utextension.utk.edu/publications/pests/default.asp
- The Black Widow Spider. PB 1193
  http://www.utextension.utk.edu/publications/pests/default.asp
- Chemical and Non-chemical Management of Fleas. PB 1596.
  http://www.utextension.utk.edu/publications/pests/default.asp
- Suggested Guidelines for Managing Pests in Tennessee's Schools: Adopting Integrated Pest Management). PB 1603.
  http://www.utextension.utk.edu/publications/pests/default.asp
- Managing Nuisance Animals and Associated Damage Around Your Home. PB 1624.
  http://www.utextension.utk.edu/publications/pests/default.asp
- Managing Structure Invading Ants. PB 1629.
  http://www.utextension.utk.edu/publications/pests/default.asp
- European Hornets Tapping at Your Window at Night?. SP 290A.
  http://www.utextension.utk.edu/publications/pests/default.asp
- Boxelder Bug and Red-shouldered Bugs. SP341H.
  http://www.utextension.utk.edu/publications/pests/default.asp
- Carpet Beetles. SP 341I.
- Clothes Moths.. SP 341J.
  http://www.utextension.utk.edu/publications/pests/default.asp
- Yellowjacket Wasps in Tennessee. SP 341M.
  http://www.utextension.utk.edu/publications/pests/default.asp
- Silverfish and Firebrats. SP 341O.
  http://www.utextension.utk.edu/publications/pests/default.asp
- SP 341P - Carpenter Bees
- Head Lice. SP 341S.
  http://www.utextension.utk.edu/publications/pests/default.asp
- Mud Daubers and Cicada Killers. SP 341T.
  http://www.utextension.utk.edu/publications/pests/default.asp
- Mosquito Control Around Homes. SP 503B.
  http://www.utextension.utk.edu/publications/pests/default.asp
- Lady Beetles Infesting Homes. SP 503C.
  http://www.utextension.utk.edu/publications/pests/default.asp

Additional Websites

- Household Pests, University of Fla
  http://edis.ifas.ufl.edu/MENU_IN:HOUSEHOLD
- Featured Creatures, University of Fla and Fla Dept. of Ag. and Consumer Services
  http://creatures.ifas.ufl.edu/
- School IPM website, University of Florida
  http://schoolipm.ifas.ufl.edu/
- Structural, Industrial and Medical Insects, University of Kentucky,
  http://www.uky.edu/Agriculture/Entomology/entfacts/efstruc.htm

- OhioLine ,Ohio State University Online search http://www.ag.ohio_state.edu/%7Eohioline/index.html
- Fire Ant web site, Texas A & M http://fireant.tamu.edu/index.html

Commercial Websites for Pest Management Professionals

- Pest Control Magazine http://www.pestcontrolmag.com/
- Pest Control Technology http://www.pctonline.com/
- National Pest Management Association http://www.pestworld.org/
- Pest Web http://www.pestweb.com/

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Manuals and Keys:

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- Koehler, P. Pests In and Around the Home. IFAS Publications, P.O.Box 110011, University of Florida, Gainesville, Fla 32611-0011 or http://infotech.ifas.ufl.edu/software/pests_cd.html

Field Guides

- Hedges, S. Pest Control Technology Field Guide for the Management of Structure-Infesting Ants. Franzak and Foster Co., Cleveland, Ohio.
- Hedges, S. Pest Control Technology Field Guide for the Management of Structure-Infesting Flies. Franzak and Foster Co., Cleveland, Ohio.
- Hedges, S. Pest Control Technology Field Guide for the Management of Urban Spiders. Franzak and Foster Co., Cleveland, Ohio.
- Hedges, S. and M. Lacey. Structure-Infesting Beetles. Volume 1: Hide and Carpet beetles/Wood-Boring Beetles. Franzak and Foster Co., Cleveland, Ohio.
- Hedges, S. and M. Lacey. Structure-Infesting Beetles. Volume 2: Stored Product Beeltes/Occasional and Overwintering Beetles. Franzak and Foster Co., Cleveland, Ohio.
- Smith, E and R. Whitman. 1992. NPCA Field Guide to Structural Pests. NPCA, Dunn Loring, Va.

General identification guides for insects.

- Petersons Field Guide: Insects of North America # 19
- Petersons Field Guide: Beetles of North America #29
- Petersons Field Guide: Moths of Eastern North America #30

Appendix B Additional Resources

Plant and Pest Diagnostic Center

The Plant and Pest Diagnostic Center is a diagnostic laboratory whose services are provided by the University of Tennessee Extension. The center is located in Nashville, with six Extension specialists onsite at the facility. Other specialists are available in Knoxville and Jackson to assist in difficult diagnoses. Services include plant problem diagnosis, insect and weed identification, fescue endophyte testing and nematode analysis. Other tests are conducted on a seasonal basis, such as virus testing.

It is requested that all specimens be forwarded to the diagnostic laboratory through the local county Extension agent. Often an identification can be made at the local level, resulting in faster response to the grower. After a diagnosis is made, the form (minus the lab copy) will be returned to the county agent. The county agent can evaluate the laboratory diagnosis and make any changes or additions that are necessary before the grower copy is returned. All county Extension offices have a supply of mailing materials (padded envelopes, address labels, insect vials and mailing tubes) and appropriate specimen forms (Form 654 - Insect & Plant Disease Specimen Form, Form F740 - Fescue Endophyte Specimen Form, Form 738 - Nematode Sample Form and Form 733 - Plant and Soil Science Weed Identification and Control Form). Additional forms and mailing materials can be provided to the county offices by the Plant and Pest Diagnostic Center.

COLLECTING AND PREPARING SPECIMENS FOR MAILING

1. Fill out the appropriate form as completely as possible. On the back of each form are directions for collecting the kind of sample that is needed for diagnosis.
2. Send generous amounts of material; wrap plant material in dry paper and enclose plant material in plastic bags; never add water to any sample. Never mix several host species or different problems in a single bag; do not have any loose soil in the bag with plant material. **Never put the specimen form in the same bag as the plant material or soil.**
3. Send specimens immediately after collecting. If holdover periods are encountered, refrigerate the specimen. Mail packages to arrive on weekdays rather than during the weekend.
4. Protect specimens from being crushed in the mail. Place **insects** in a vial with alcohol or insect preservative and send in a mailing tube. Collect at least two or three insect specimens from the same location. Do not place moths, butterflies or any adult insect with wings in alcohol. Place them in a killing jar and then transfer them to a small crushproof container for mailing. Mites, thrips and scale insects should be sent on the host plant material, packaged as you would diseased plants. If possible, small caterpillars, grubs and maggots should be sent live in a plastic bag with some of the host material.
5. If a **general decline or dying of plants** is observed, send whole plants showing early symptoms, with roots and adjacent soil intact. Dig plants up carefully - do not pull up. If a field crop, send several plants. Tie a plastic bag around the roots and soil to keep soil from deteriorating the foliage. If it is not possible to send whole plants, send a generous sample of above-ground portions showing early symptoms. For die-back and general decline, the lower stem and roots with attached soil are the most useful part of the plant. If it is not possible to send the lower stem, send at least a pint of soil and a good handful of small feeder roots. Do not allow the roots to dry out.
6. When **localized infections** such as cankers, leaf spots and rots are involved, send specimens representing early and moderate stages of the disease. Include healthy portions of the tissue from above and below the diseased area. Fleshy specimens should have a **DRY** paper towel in the plastic bag with the specimen, especially in hot weather. This will absorb any excess moisture. In hot weather, punch several holes in the plastic bag for ventilation. Fleshy fruit and vegetables should be wrapped separately. Paper towels are better wrappings, but brown paper and newspaper are good. Keep all specimens cool.
7. Soil collected for **nematode analysis** should be placed in a plastic bag and tied to keep from drying out. Special bags are available. Do not allow this soil to get hot, as this will affect the results of the nematode analysis. About a pint of soil is needed for the basic nematode test and about a half gallon of soil is needed for the soybean cyst nematode race determination test. See the back of Form 736 for sampling methods.
8. **Weed specimens** for identification should be complete plants which have leaves, stem, roots and either flowers or fruit. Wrap the roots and stem of the plant in a moist (not soaking wet) paper towel, then wrap loosely in a plastic bag and put in a box or padded envelope adequate to prevent crushing. Blot excess moisture from aquatic plants and wrap as above.

HANDLING FEES FOR SAMPLES

1. **Nematode Samples:**
   A. **Basic soil sample** - $5 each ($15 out-of-state). Nematodes will be extracted from the soil and/or root tissues and the populations of plant parasitic types will be determined to genus. Requires 1-2 weeks.
   B. **Soybean Cyst Nematode Race Determination** - $15 each ($25 out-of-state). A determination of the race(s) of soybean cyst nematodes present in a soil sample will be determined by growing differential soybean varieties in soil samples in the greenhouse. Requires 60-80 days.
2. **Fescue Endophyte Samples:**
   A. **Tissue staining test** - $15 each ($25 out-of-state). Tissue from a specified number of tillers will be stained and observed for the presence of the fungus endophyte. A percent of tillers infected will be determined. Requires 2-3 weeks.
   B. **Seed staining test** - $15 each ($25 out-of-state). Freshly harvested seed will be stained and observed for the presence of the fungus endophyte. A percent of infected seed will be determined. Requires 2-3 weeks.
   C. **Seed grow-out test** - $20 each ($30 out-of-state). Seed that is one year old or older will be planted in the greenhouse. Tissue from developing seedlings will be stained and observed for the presence of the fungus endophyte. A percent infection will be determined. Requires 14-16 weeks.
3. **Weeds, Diseases and Insect Samples:**
   A. **Diagnosis or Identification** - Samples submitted by Extension staff. No charge.
   B. **Diagnosis or Identification** - Samples submitted by persons other than Extension staff. Simple visual identification (including microscopic identification). No charge.
   C. **Diagnosis or Identification** - Plant and pest samples requiring incubation, rearing, isolation, culturing, virus tests, serological tests, host inoculation, extensive keying for identification and/or other recognized laboratory and greenhouse procedures. Requires 1-3 weeks. $10 each ($20 out-of-state). Notice of charge will be given in advance of testing.
   D. **Contractual Agreement** - Special arrangements will be required for individuals, consultants or commercial organizations requesting disease diagnoses or pest identification on large numbers of samples. Charge to be determined in advance.

Make all checks payable to **THE UNIVERSITY OF TENNESSEE**

SHIPPING INFORMATION

All specimens should be mailed to

Plant and Pest Diagnostic Center
University of Tennessee Extension
5201 Marchant Drive
Nashville, TN 37211-5112

Samples shipped other than by the U.S. Postal Service (via UPS or Federal Express) should be sent to a different zip code address: 5201 Marchant Drive, Nashville, TN 37220.

The diagnostician position at the Plant and Pest Diagnostic Center is currently vacant. Some services may not be available at the time of your request. **Rates are subject to change.** Please contact Dr. Frank Hale at (615) 832-6802 or fahale@utk.edu for current fees and services.

Distance Diagnosis through Digital Imaging

Introduction

The *Distance Diagnosis through Digital Imaging System* at the University of Tennessee, Agricultural Extension Service will allow text-based information and digital images to be submitted from county Extension offices for rapid diagnosis by resource professionals at the Plant and Pest Diagnostic Center, in Nashville. County Extension faculty are trained to submit plant disease or pest images and information using digital cameras, microscopes, computers and the internet. The system uses conventional software and hardware proven to be effective and reliable.

Several Imaging stations have been distributed geographically in county Extension offices across Tennessee. Additional stations will be placed in other counties as funding becomes available. *Distance Diagnosis* will reduce diagnostic turn-around time from an average of four days to one day when compared to sending physical specimens through postal mail. Digital images of plant disease, insect and weed pests can be uploaded to the *Distance Diagnosis* Web page and diagnosed within one hour in emergency situations. Diagnostic responses will be provided on the internet, or by phone, FAX or email.

Project Benefits

Agribusiness enterprises that depend on timely pest identification, save money as they are able to respond quickly to emerging disease, insect or weed outbreaks.

County Extension agents will strengthen their diagnostic skills and become more valuable resources in their communities.

A library of images is currently being constructed and will serve as a crop pest profile reference library. This will be available as an educational resource for Extension agents, undergraduate and graduate students, farmers, nursery workers, golf course superintendents, landscapers, Master Gardeners and pest management professionals.

Distance Diagnosis utilizes the expertise of faculty located across the state. These faculty members work with various disciplines and their expertise helps improve accuracy and efficiency of diagnostic responses.

Special arrangements will be required for individuals, consultants or commercial organizations requesting disease diagnosis or pest identification on large numbers of samples. Charges will need to be determined in advance of these submissions.

For more information concerning this program contact fahale@utk.edu or dhensley@utk.edu.