

About this manual

This manual was prepared for use in U.S. Environmental Protection Agency (EPA) Pesticide Applicator Training Programs and is intended to provide the information needed to meet the minimum EPA standards for certification of commercial applicators in Category 7B — Wood-Destroying Pest Management — under the Federal Insecticide, Fungicide, and Rodenticide Act. It also prepares trainees for an examination, based on this manual, administered by state departments of agriculture. It is intended for use as a supplement to the Pesticide Applicator Training core manual in your state.

This manual does not provide all of the information you need for safe and effective use of pesticides. Examine the label for each pesticide you use. Labels must list directions, precautions and health information — all of which are updated regularly when a pesticide is registered for use. If information on a current pesticide label conflicts with information in this manual, follow the label. Manufacturers will supply additional information about products registered for use in your state.

Pesticide Applicator Training Programs are cooperative efforts. State departments of agriculture are the state lead agencies. State Extension programs are responsible for the content of the training. The EPA and state departments of conservation, health, natural resources, and transportation also contribute to the development of educational materials and participate in the training program.

On the World Wide Web

This publication is available as an electronic document at <http://extension.missouri.edu/explore/manuals/m00096.htm>

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Development of this manual was funded wholly or in part by the United States Environmental Protection Agency under Assistance Agreement BG-99781606 to the Missouri Department of Agriculture (MDA). It has been subjected to the Agency's product and administrative review and has been approved for publication as an EPA product. Mention of trade names of commercial products does not constitute endorsement or recommendation for use.

Wood-Destroying Pest Management

Category 7B

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University of Missouri Extension - 2007

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PREFACE AND ACKNOWLEDGMENTS

This manual is the first edition of *Wood-Destroying Pest Management*. In Missouri it replaces a collection of information sheets assembled to give information about wood-damaging pests. It is jointly published by University of Missouri Extension, the Missouri Department of Agriculture, and the U.S. Environmental Protection Agency. It seeks to establish a minimum level of information that commercial pesticide applicators should know in order to become certified in category 7B. Although published in Missouri, the manual is written with the intent that other Midwestern states within U.S. EPA Region VII could use it for category 7B training and certification.

The manual *Wood-Destroying Pest Management* was written for pest management professionals who work as inspectors, pesticide technicians, supervisors, owners, or others specifically employed in the area of structural pest management and who provide wood-destroying insect management services. The manual emphasizes inspection, identification, basic biology and management of the most common insect pests of wood in human structures. These pests include termites, beetles, ants and bees. Prior to certification in wood-destroying insect control, commercial pesticide applicators should have core training in pesticide labeling, formulations, environmental concerns, personal protective equipment, mixing pesticides, applying pesticides, calibration, etc. This manual does not give specific training in these areas, but talks about these concepts within the context of wood-destroying insect control.

There are five chapters in *Wood-Destroying Pest Management*. The first chapter discusses the importance of a good inspection and includes a sample of the National Pest Management Association's Wood Destroying Organism Report Form (NPMA-33) and instructions about how to use it. Structural features that are inspected each time you do an inspection are listed in this chapter, and information regarding what to do about inaccessible areas is given. Finally, common equipment used in wood-destroying insect management is described. Chapter 2 examines

termite identification, biology, infestation, prevention and management. Basic building construction practices are mentioned as they relate to termite soil treatment strategies, termiticide application standards are outlined, and information about wood treatments and baiting is given. Chapter 3 discusses common beetle pests of structural wood. It explains identification of these beetles both as adults and larvae, describes their damage, and gives information about their management. Chapter 4 gives this same information about carpenter ants, acrobat ants and carpenter bees. The last chapter gives a brief overview of fungi that damage wood in structures. The intent of this short chapter is to give background information about the basic types of fungi that may be encountered, but no control information is given since certification in category 7B does not include management of fungi in homes.

Acknowledgments

Richard Houseman and Clare Adrian wrote initial drafts of each chapter. Dale Langford edited and designed the publication. Dennis Murphy created the original artwork and graphics not otherwise credited to scientific illustrators Joe MacGown at Mississippi State University and Chris Jung at the Pennsylvania State University. The project coordinator was Wayne Bailey. The author would like to thank John Brunnert and Darryl Slade at the Missouri Department of Agriculture, Dick Wiechman and Walter Roachell at the U.S. Environmental Protection Agency, and Dave Baker at University of Missouri Extension for their interest in and support of this project.

Several books and pesticide applicator training manuals were consulted in the preparation of this manual. The following publications are among the primary sources used:

- *Management of Wood-destroying Pests*, Manual E-2047, Michigan State University Extension

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- *Control of Termites and other Wood Pests*, Manual B-5075, Texas A&M University
 - *Wood Destroying Organisms for the Commercial/Non-commercial Pesticide Applicator*, University of Nebraska Cooperative Extension Manual
 - *Handbook of Pest Control* by Arnold Mallis
 - *An Introduction to Wood-Destroying Insects* by Harry Moore
 - *Truman's Scientific Guide to Pest Control Operations* by Gary Bennett, Robert Corrigan and John Owens
 - *Termite Biology and Control* by Tamara Cook, Jerry Cook, and Roger Gold
 - *Common Sense Pest Control* by William Olkowski, Sheila Doar, and Helga Olkowski

Extension information from California, Kentucky, Minnesota, Pennsylvania, South Carolina, and Virginia also aided in preparing this manual.

Permission was granted to use illustrations from Penn State Cooperative Extension and Mississippi State University Cooperative Extension Service publications.

INSPECTIONS AND EQUIPMENT

The purpose of inspecting for wood-destroying organisms (WDOs) is to determine the presence and type of pest(s), estimate the extent of damage, note any conditions that contribute to making the structure susceptible, and document evidence of any previous treatments or infestations. A good inspection is critical to good control of wood-destroying insects. The information you gain during an inspection sets the course for both the nature and the extent of any management strategies. A meaningful and thorough inspection builds customer satisfaction and a good reputation, while a hurried or shoddy inspection can damage your reputation and increase the risk of lawsuits. This section provides basic guidelines for wood-destroying organism inspections.

Tools

The following tools are helpful when making a thorough inspection for wood-destroying organisms:

- Wood-destroying organism (WDO) report form (see pages 15–21)
- Flashlight
- Mechanic's mirror for hard-to-see areas
- Knife or similar instrument to probe into suspicious wood, cracks and crevices
- Screwdriver to remove vents and as a sounding tool to determine the condition of wood
- Ladder to reach eaves, attic and roof
- Tape measure to record the size of the structure and location of infestations
- Moisture meter to detect areas conducive to activity by wood-destroying organisms
- Protective clothing (e.g., hard hat, dust mask, gloves)
- Notepaper
- Books or other reference materials

In addition, certain tools are designed specifically for WDO inspections. The following tools are not as common as those listed above because of their cost:

- Specially trained dogs

- Acoustic sensors
- Infrared scanners
- Motion detectors

Homeowner

The inspection process should always begin by obtaining as much information from the client as possible. Listen carefully to homeowners as they tell you when, where and why they need an inspection. Answer any questions they might have and ask for additional information you might need, such as:

- Date and time they first saw insects, swarms or damage
- Dates of, or knowledge about, previous treatments or infestations
- Age of the structure
- Length of time they have owned the structure
- Type of construction (slab, crawl space, basement)
- Location of heating, plumbing, electrical lines
- Remodeling, repairs or new construction
- Drainage or moisture problems
- Location of drinking water source and any other permanent water sources nearby

Inspection guidelines

Begin the actual inspection by measuring the exterior of the structure and diagramming its dimensions, including porches, patios, planters, air conditioning slabs and other adjoining structures. Note gardens or landscaping on your diagram. Record the foundation type as slab, basement or crawl space.

If the home is built on a slab, determine the slab type (monolithic, floating or suspended). Remove the door sill plate and examine the slab underneath for a seam that represents the expansion joint. If you do not see an expansion joint underneath, it is a monolithic slab. If there is an expansion joint, it is either a floating or suspended slab, which means there are potential termite access points around the perimeter of the slab.

Always show respect for homeowners' property and possessions. Don't move things without permission or let pets in or out of the home. It is also important to keep the structure clean by inspecting the cleanest areas first and moving to gradually dirtier areas during the inspection. This minimizes the chance of transporting dirt and grime from dirty areas into the clean areas and saves cleanup time.

Interior inspection

Inaccessible areas — Only about 35 percent of an average home is available for inspection, the rest is visually obstructed due to construction methods, adjoining structures, or immovable materials. You must record these areas as inaccessible on your report if you are not able to inspect them adequately. You should also explain to the homeowner any limitations that prevented you from inspecting inaccessible areas of the structure.

Living areas — Begin the inspection here. These are usually the cleanest areas. As you inspect the interior, add the location of interior rooms to your original diagram. Note the location of infestations you find along with other important structural details such as plumbing, vents, remodeling, inaccessible areas, cracks in the foundation and other helpful observations.

Probe cracks, crevices and expansion joints in concrete to determine if they may serve as potential entry routes. Look for small gaps caused by expansion and contraction of the slab around ducts or pipes, and record any water condensation around pipes. Note moist conditions or signs of them such as leaks, missing grout or water stains. Check these areas with a moisture meter. Bath traps under bathtubs on slabs and in basements should always be checked during inspections because this is one of the most common termite entry points in a structure. Also open heating/cooling vents and examine the ductwork. Note inaccessible areas on your WDO report.

Lightly probe and tap on baseboards, door frames, window frames and wooden moldings on all interior walls to determine if they appear hollow. Critical areas are around water and utility pipes, as well as areas next to raised porches and planters. Framing around front doors is also frequently infested and should be checked because wood scraps are often left under porch stoops during construction. In addition, examine wood flooring and the underside of floor coverings wherever possible. Pay attention to darkened or raised areas and holes in carpeting or sunken areas under linoleum where damage to wood may have occurred. Note any inaccessible areas on your WDO report.

Basement — Your inspection of basement walls should be similar to, but more careful than, your inspection of main floor walls because they are in direct contact with soil. Look outside for cracks in the

foundation and inspect them thoroughly. Any cracks in the foundation can serve as termite entry points. These entry points may be obscured by wall coverings and windows in finished basements. Without any of the specialty tools for detecting termites, you can examine these walls by sounding and probing wood in the basement.

One of the most common routes of infestation by subterranean termites is through stair stringers that are embedded in the concrete floor of basements. Be sure to check the gaps between the concrete and the stringer and probe the base of the stringer thoroughly to detect any damage.

Remove tiles from the ceiling to examine floor beams. If ceiling tiles cannot be removed, note the area as inaccessible on your report.

Examine pipes for moisture content and look for water damage. Look for stress cracks around heaters and boilers. Note areas with poor ventilation or high humidity on your report.

Attic — Attics can provide clues to problems in other areas of the structure. Look for weakened wood, mud tubes, and evidence of moisture problems due to roof leaks, poor ventilation, air conditioning condensation, etc.

Special—Fireplaces typically rest on their own slab that is placed next to the slab of the home. Fireplace slab footings are normally in direct contact with soil and there is an expansion joint between this slab and the main slab of the home. You need to inspect these expansion joints and any other gaps between the fireplace slab and the home slab.

Exterior inspection

Wood contact — Inspect any wood in contact with soil. A good guideline for grade level around the perimeter of the house is for soil to be at least 6 inches from the sill plate. Indicate on your report any wood to soil contact, or if structural wood is below the soil surface. Also pay attention to aboveground planters and to flower beds that are adjacent to the foundation. These are areas where a previous soil insecticide treatment may have been made and the barrier was disrupted. This could leave a structure vulnerable to entry by subterranean termites.

Several sources of cellulose near the structure outdoors may serve as a food source for wood-destroying organisms. They include mulch, firewood, lumber, fences, trellises, wooden flower boxes, shrubs and trees. When any of these wood sources are associated with ventilation ducts or water pipes, insects can use these openings into the structure for entry. The presence of moisture around a structure is conducive to infestation by wood-destroying organisms. Inadequate drainage is a primary source. Clogged gutters, improperly channeled downspouts, misdirected sprinkling systems, leaking pipes, poorly

placed air conditioner drip lines and leaking or dripping faucets and hoses can contribute to creating and maintaining conducive conditions for termite activity around a structure.

When wood and moisture sources occur together, there is an especially good situation for invasion by wood-destroying insect pests.

Mud tubing — Note, but leave undisturbed, any mud tubing that serves as a transport channel between the soil and the wood and indicates the presence of termites, as discussed later in this publication.

Stucco and other veneers — Stucco can be applied to a house frame using chicken wire or with block construction, outside a layer of Styrofoam insulation. If stucco is loose at the base, tap it to determine if the area beneath is hollow and possibly accessible to insects. Brick veneers often rest on a ledge of the foundation wall. Inspect it, if below grade, with suspicion.

Roofs — Look for sagging areas of the roof, examine eaves, soffits, and fascia boards, especially at junctions and corners.

Crawl spaces — It is often difficult to maneuver within a crawl space where the overhead flooring is close to the soil, but inspecting this area is important because the crawl space is an ideal entry point for wood-destroying organisms, especially termites. Examine all perimeter foundation walls, interior bearing walls, pillars, the chimney base and areas around pipes. Look for wood damage or insects especially around high-risk areas adjacent to planters, porches in contact with soil, crevices and cracks, and high moisture areas. Sound and probe any suspicious areas of beams and joists. Inspect any wood debris on the ground in the crawl space and advise the homeowner to remove it. Check areas closely that allow less than 18 inches clearance, using a flashlight and mechanic's mirror. *Carefully record on the inspection form any areas that are inaccessible to inspection.*

Equipment

You must be aware of the many types of pesticide application equipment available and learn how to take care of it. Proper care of equipment, including calibration, maintenance and repair, is essential in order to make accurate pesticide applications. Failure to care for equipment can cause serious problems and result in misapplied pesticides. Accidents from faulty equipment result in lost time, illness, complaints and lack of confidence from clients.

Pesticide application equipment used in urban pest management is, for the most part, time tested and reliable. However, to use pesticides efficiently and economically and to avoid under-application or over-application, applicators must understand the capabilities of their equipment and be able to calibrate it

correctly. Calibration lets you know how much pesticide is being applied by your equipment to a given area during a given time. Applying too little pesticide is ineffective and applying too much is unsafe.

Calibration involves a few simple steps:

- Accurately measure the amount of pesticide in your tank or container.
- Apply the pesticide to a given, premeasured area while maintaining a certain rate of delivery or pressure.
- Measure the amount of material required to fill the tank or container back to the original level.
- Divide the amount of pesticide used by the area or distance covered to get the application rate.

Ideally, you should calibrate your equipment before every application because clogging, corrosion, or wear will change the delivery rate. The settings may also change or gradually fall out of adjustment. Differences in pressures and nozzles will also affect the amount of pesticide applied to an area. Be alert for possible calibration changes each time you use your equipment. During each application be aware of the amount you are using and whether that amount approximates what you calculated would be used for the job. If you notice that you are applying more or less than the amount you calculated, stop and check your calibration.

The equipment most commonly used for managing infestations of wood-destroying organisms includes the following:

- Hand-held compressed air sprayers
- Power sprayers
- Aerosol or fog generators
- Bait stations
- Traps, monitoring devices, etc.

Hand-held compressed air sprayers

The small (1- or 2-gallon) stainless steel spray tank is the workhorse of pest control (Figure 1-1). It is the tool most familiar to pest control technicians. It can be used in many different ways (and by many different industries). In pest management, the spray tank is used to apply a flush-

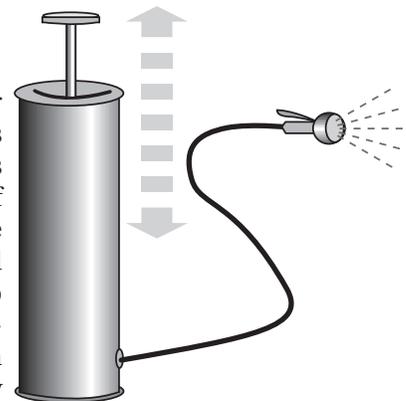


Figure 1-1. Hand-held compressed air sprayer. This sprayer can deliver pesticides at a wide range of pressures, depending on the amount of air pumped into the canister. Low pressure is normally recommended for spray applications inside structures.

ing agent, or a residual pesticide. Depending on the nozzle selection, it applies different spray patterns; and depending on the amount of pumping, it delivers the pesticide under high or low pressure.

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

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

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

Spray tank air pressure varies according to the amount of air the technician pumps into the tank. Pressure gauges can be attached to spray tanks. Low pressure is usually recommended for spray application inside structures. Constant use of high pressure with compressed air sprayers sets up the possibility of overuse and misapplication. It causes part of the sprayed liquid to break into droplets as soon as it exits the nozzle; this wastes material that can drift onto nontarget surfaces. High pressure also causes splash back on surfaces or quickly traps air in crevices and keeps the pesticide from entering small spaces. As well as being uneconomical and wasteful, the practice encourages rapid application of pesticides whether they are needed or not, from distances that affect accuracy. This style of pesticide application seldom results in effective pest control.

Technicians who use hand-held compressed air sprayers should periodically receive training for sprayer maintenance and cleaning. It is recommended that they familiarize themselves with their own equipment and be prepared to repair it. It is recommended that technicians

- Rinse the sprayer daily; especially the hose. (Always empty liquid from the hose: hold the nozzle high and squeeze the trigger to drain the hose into the tank. If this is not done, liquid from the last use remains; it will be applied first at the next use, regardless of any new spray mix in the tank.)
- Clean the sprayer on a regular schedule.

- Never use warm water to mix sprays. (Warm water helps break down pesticides, creates droplets that easily float, and increases a pesticide's odor.)
- As stressed in the core manual, always use gloves when spraying. Always use safety glasses of goggles when treating areas above your head or close to your face.

Power sprayers

Power sprayers use electric or gasoline engines to pump liquid insecticides from a sizable tank, usually over 100 gallons (Figure 1-2). Low pressure is recommended when using a power sprayer because it allows for a more careful application and gives better soaking

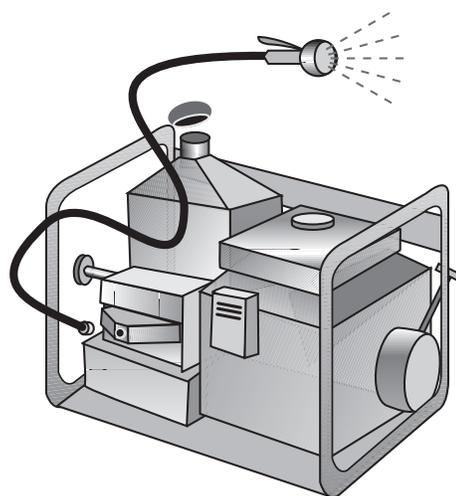


Figure 1-2. Power sprayer. This sprayer uses an electric or gasoline engine to pump large amounts of pesticide from a tank at various pressures. Low pressure is recommended for soil applications around structures.

action and penetration into the substrate. The liquid is discharged through a hose of sufficient length to reach from the pump to the application site. Power sprayers are generally used for controlling termites.

You need to know the proper amount of pesticide that is being applied. Accurate calibration of power sprayers lets you know how much pesticide you are applying. Higher than recommended doses can contaminate an area or result in runoff. Less than recommended doses may fail to control the pest. It is estimated that 60 percent of sprayers have a calibration error up to 10 percent. Calibration should be a part of every treatment because applications vary depending on pressure, nozzle tips, etc. Flow meters can also be helpful in letting a technician know the output of a sprayer over time.

Regularly inspect the hose on power sprayers. Worn spots or cuts can allow hoses to burst, causing a pesticide spill and contamination. Know where the shut-off valve is located and make sure it is always in good working order. Always carry equipment in the

service truck to take care of spills.

Canned insecticides

Pressurized cans of insecticides (Figure 1-3) became common in the late 1940s and were first used as aerosol foggers or “insect bombs.” Canned insecticides in urban pest management include canned aerosol foggers (volumetric sprays, total release fogs) and pressurized liquid sprays. (The over-the-counter aerosol generally sold to the public for contact spraying is not included in either of these categories.)

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

Canned pressurized liquid sprays — These liquid sprays are not aerosols. These are coarse wet sprays. Because the spray is not made up of aerosol droplets, little becomes airborne. Compressed gas mixes with the liquid of a pressurized spray and forces the pesticide through the exit port, where it quickly vaporizes and leaves pesticide on surfaces. When canned pressurized liquids are part of a system that includes crack and crevice nozzles, the insecticide can be placed precisely on the target area. In a closed crevice, the expanding gas propels the insecticide in all directions, forcing it on all surfaces in the crevice, rather than shooting it across in a straight line like a compressed air sprayer. Canned pressurized liquid sprays can be excellent tools if you understand the target pests’ habits and harborage that can be treated.

Aerosol or fog generators

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

Cold foggers — These machines break insecticides into aerosol-sized droplets and propels them into



Figure 1-3. Pressurized can sprayer. This common sprayer can be used to apply aerosol or liquid pesticides at high pressure.

the air as a light cloud. Large ultralow-dosage (ULD) and ultralow-volume (ULV) cold foggers are typically mounted on trucks and used for mosquito control programs. They have also been used to control pests in large structures, such as warehouses. Cold fog generators drive pesticidal fog over a relatively large area. Droplets fall on flying or resting insects and are deposited in very small amounts on plant leaves where insects rest. Handheld cold foggers are used inside buildings, where they fill rooms, small warehouses, etc., with aerosol droplets. These floating droplets kill flying insects as well as exposed insects on horizontal surfaces. Fogs do not enter tight spaces or cracks and crevices. Aerosol generators used for crack and crevice applications may also produce aerosol droplets that float in the air.

Thermal foggers — These machines use heat to vaporize oil in an oil-based insecticide to make a light cloud (Figure 1-4). Large truck-mounted thermal aerosol generators are used in mosquito control programs to produce an insecticide fog that is moved across open spaces by air currents and kills flying insects. Indoors, portable thermal foggers work like cold foggers except that the droplets are smaller.

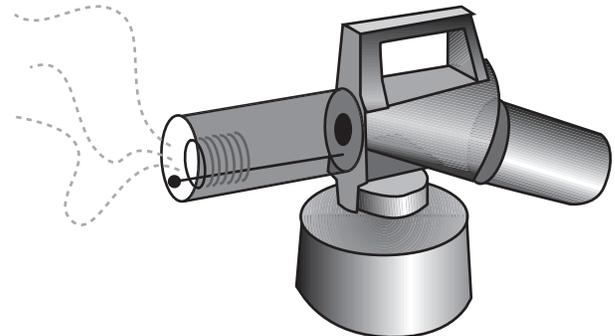


Figure 1-4. Thermal fog generator. This sprayer uses heat to vaporize oil in oil-based pesticides and makes an aerosol fog that can be used to fill enclosed spaces.

Precautions to take when using foggers or aerosol-generating equipment indoors:

- Applicators should wear respirators.
- Occupants must leave until the area has been adequately ventilated.
- Pets must be removed; houseplants and aquariums must be covered, and aerating pumps turned off.
- Exposed foods and food preparation surfaces must be protected. After treatment, food preparation surfaces and any exposed utensils must be washed.
- Pilot lights and any other open flame must be extinguished. This is particularly critical when the oil-based thermal fog is used. Any spark can ignite a thermal fog atmosphere.

- Thermal fog generators can burn surfaces that are contacted, including the operator.
- Aerosol droplets will not move into spaces where air is not circulating nor into any dead air cracks and crevices (e.g., under molding into partially closed cabinets, drawers, closets.)
- Furnace, air conditioning, and ventilation equipment should be turned off. (Ventilation will evacuate the insecticide and may carry it to other places outside the target area.)
- After an appropriate interval, and before people or pets reoccupy the area, treated rooms should be thoroughly aired.

Fogging should not be used as a single method of treatment but instead should supplement other types of application. If fogging treatments become necessary at increasingly closer intervals, the pest population is not being suppressed and other measures need to be implemented.

Dusters

A duster applies a fine, dry layer of a powdery mixture containing pesticide. Dust applied on porous surfaces is not absorbed as liquids are, but instead, it rests on surfaces. This dust accumulates on the body (insect hairs, legs and mouthparts) of insects that touch it. Pesticides in dusts are absorbed by the pest in the same way as liquid sprays. If the pest ingests particles (when grooming or cleaning itself), the dust can also cause stomach poisoning.

Dusts can be placed in wall voids, crawl spaces and almost any unused space. Sometimes drilling into voids is necessary to inject dust. Great care must be taken to confine dust so that it does not drift and is not carried into nontarget areas. Remember to turn off pilot lights and flame- or spark-producing equipment if a combustible dust is used. Protect smoke alarms when using dust. Dusters clog easily. They must be agitated often, kept dry at all times, and washed and dried frequently.

Three types of hand dusters are commonly used by pest management technicians: bulb, bellows and plunger dusters. Dusts can also be propelled by compressed air in some formulations of canned insecticide and are thus applied like canned liquid pesticides. Bellows dusters consist of a closed rubber cylinder made rigid by an internal spring, with a

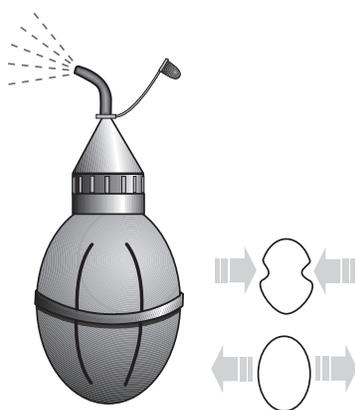


Figure 1-5. Bulb duster. This sprayer is used to apply pesticide dusts to cracks, crevices and other enclosed spaces.

spout at one end and a refill hole at the other. These dusters, originally called Getz dusters, are held with the spout at the top. A slight pressure from top and bottom pushes air and dust from the spout. The more pressure applied, the more dust ejected. The spout is tapered at the tip and slight puffs propels small amounts of dust into cracks and crevices. Bulb dusters (Figure 1-5) have a rubber bulb with a removable spout at one end. The spout screws off to allow for refilling. Dust application is much like the bellows duster except that the bulb is squeezed. Both dusters come in several sizes.

Plunger dusters (Figure 1-6) hold more dust than either bellows or bulb dusters. Plunger-type dusters have been used for garden dusting for a century, but the plunger duster used in urban pest management is smaller, made of high-impact plastic, and has several

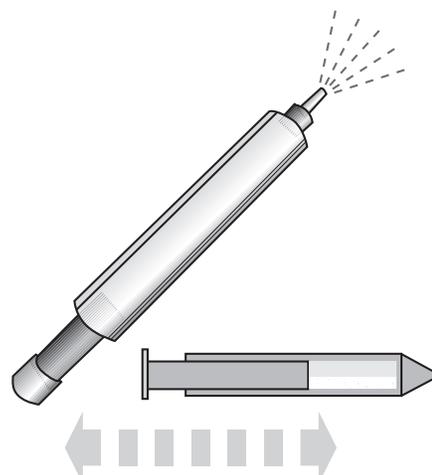


Figure 1-6. Plunger duster. This sprayer is used to apply larger amounts of dust to enclosed spaces.

styles of nozzles.

Power dusters use compressed air to deliver insecticidal dusts into large spaces. Even fire extinguishers have been converted to dusters and filled with compressed air. Other kinds of dusters are made of plastic and are pumped up like the handheld compressed air sprayer used to apply liquids. These plastic dusters release small or large amounts of dust with better control than the fire extinguisher type. Power dusters are often used in sewers as contact pesticides and in trash chutes of high-rise buildings. The dust is introduced at the lowest level of a trash compactor and rises up through the chute where it is vented at the top. The chute must be closed at each floor.

Traps

Traps have been used for pest control for centuries. They range from snap traps to boxes that use trapdoors, spring-loaded multiple-catch traps, and small animal traps. Bait stations are containers that hold poisonous feeding matrix. Under certain condi-

tions, they must be tamper-proof for safety. Traps can be designed in such a way that pests can enter and not get out. Fly traps are sticky tapes or cylinders that hang vertically, taking advantage of the fly's tendency to cling to vertical poles, strings, etc. Electric fly traps are made with an attracting light that lures flies to electrocution grids or glue boards. Sticky traps, such as small glue boards, can be used to catch cockroaches, to monitor roach populations and to survey for other pests.

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

Bait stations contain toxic substances that are mixed with attractive food sources. The bait stations themselves may also offer natural harborage. Baits can augment sprays, dusts and fogs, or they can be used in place of other, more toxic formulations. The key to using these devices is to know where and how to place them.

Pesticides

The chemical agents used to kill or control insect pests can be naturally occurring, but most often in the pest control industry they are synthetic. Some are ingested by the organism, some are absorbed through the insect's outer covering or integument, while others, such as fumigants, enter the respiratory system. The most common forms of pesticides used to control wood-destroying organisms are liquids, baits and fumigants.

Liquids — Liquid pesticides can be applied directly to wood to protect it from wood-destroying organisms. Often, liquid pesticides are applied to the soil around or underneath the structure for subterranean termite control. A preconstruction application of liquid termiticide can be made to soil before the cement foundation is poured. The soil around and under the foundation can also be trenched, drilled and treated following construction when there is a termite infestation. The liquid pesticide treatment to the soil creates a chemical barrier between the soil and the structure.

Liquids provide immediate protection, last several years in the soil, and are relatively inexpensive. The application is not always perfectly uniform, so there can be gaps in the treated zone. There is also a risk of contamination to soil and water if used inappropriately or if an accidental spill occurs.

Baits — Baits target the insects themselves rather than treating the soil or wood around a structure. Bait stations contain toxic substances that are mixed with attractive food sources. Some contain pheromone attractants in the form of pellets, granules or

pastes. Others contain cellulose in the form of paper, cardboard or wood. Under certain conditions, bait stations are made to be tamper-proof for safety. Bait stations themselves may also offer natural harborage for a pest.

Bait is normally a safer alternative to liquid pesticides in areas of potential contamination. Baits can augment sprays, dusts, and fogs, or they can be used in place of more toxic formulations. The key to using baits is to know where and how to place them. They must be placed in areas where populations of wood-destroying pests will find them during their normal activities. The process for baiting outdoors for subterranean termites is to install untreated wood in plastic stations regular intervals around the perimeter of a structure. When activity is detected, the untreated wood is replaced with toxic bait that is fed on and transferred to other termites. Indoors, baits are usually applied directly to an infested area.

Fumigants — These are gaseous forms of pesticide used to kill wood-infesting pests within a structure. Fumigation is effective for eliminating hidden infestations. Whole-house fumigation requires that the entire structure be covered with tarpaulins and pesticide released inside the tarpaulins for a set period of time. Several precautions must be taken during fumigation and residents must vacate the premises for two to three days during the treatment. The structure must be completely ventilated before returning to it. Special certification is required to perform commercial, whole-house fumigations.

Small fumigation chambers can be used to kill isolated infestations of wood-destroying organisms in furniture or other small items. Fumigation also does not ensure long-term control because no pesticide residual is left on the surface.

Worker protection

Pest management professionals are exposed to pesticides when mixing, loading or applying pesticides and when entering treated areas. Professional pesticide applicators have a high risk of contamination, even if exposure is limited to small amounts of pesticide, because of repeated exposure over long periods of time. The U.S. Environmental Protection Agency has established worker protection standards to reduce occupational exposure to pesticides. Worker protection standards seek to protect workers by establishing safety guidelines. Precautionary statements, requirements for personal protective equipment, decontamination instructions, emergency procedures, and storage/disposal instructions are printed clearly on insecticide labels and should be read and followed each time an insecticide is used. Below are some common statements that you will find on many insecticide labels.

Precautionary statements — Insecticides are harmful if swallowed, inhaled or absorbed through the skin. They can cause eye irritation. You should avoid contact with insecticides on your skin, eyes or clothing and avoid breathing their vapors. Always wash thoroughly with soap and water after handling insecticide, and remove contaminated clothing and wash it before reuse.

Applicators must check areas immediately adjacent to the treated structure for visible and accessible cracks and holes to prevent leaks that would result in significant exposure to people in those areas. Applicators must ensure that children and pets are not present in areas to be treated. People must be advised to stay out of these areas during treatment.

Personal protective equipment — When handling insecticides, applicators must wear a long-sleeved shirt, long pants, socks, shoes, and waterproof gloves. You must wear eyewear and a respiratory protection device when applying termiticide in a crawl space. Protective eyewear must be worn when applying termiticide by rodding or sub-slab injection.

Decontamination instructions — After application of insecticides, you are required to check for leaks. All leaks or spills that result in insecticide being deposited in locations other than those prescribed on the label must be cleaned up before leaving the applica-

tion site. You should not allow people or pets to occupy contaminated areas until cleanup is complete.

Emergency assistance — If you or a co-worker swallow an insecticide, call a physician or poison control center immediately. When you call, be sure to have the product container or label with you. If the victim has swallowed insecticide, read the label to determine whether you should induce vomiting. For termiticide in the eyes, immediately hold the eyes open and flush with plenty of water for several minutes. Remove contact lenses after the initial rinsing and continue rinsing for several more minutes. For insecticide spills on the skin or clothing, immediately take off contaminated clothing and rinse the skin for several minutes. For inhalation exposure, move the victim to an area with fresh air. If the victim has stopped breathing, call 911 for instructions.

Storage and disposal — Store all insecticides in their original containers only. Handle and open containers carefully. After partial use, replace lids tightly. Store in a cool, dry place in a way that prevents cross-contamination with other pesticides, fertilizers and feed. Dispose of excess insecticide by using it all at the treatment site, or take it to an approved waste disposal facility. Triple-rinse all containers and puncture them before disposal in a sanitary landfill. Never reuse empty insecticide containers for food or water.

Wood Destroying Insect Inspection Report

Notice: Please read important consumer information on page 2.

Section I. General Information Inspection Company, Address & Phone	Company's Business Lic. No.	Date of Inspection
	Address of Property Inspected	
Inspector's Name, Signature & Certification, Registration, or Lic. #		Structure(s) Inspected

Section II. Inspection Findings This report is indicative of the condition of the above identified structure(s) on the date of inspection and is not to be construed as a guarantee or warranty against latent, concealed, or future infestations or defects. **Based on a careful visual inspection of the readily accessible areas of the structure(s) inspected:**

- A. No visible** evidence of wood destroying insects was observed.
- B. Visible** evidence of wood destroying insects was observed as follows:
 - 1. Live insects (description and location): _____
 - 2. Dead insects, insect parts, frass, shelter tubes, exit holes, or staining (description and location): _____
 - 3. Visible damage from wood destroying insects was noted as follows (description and location): _____

NOTE: This is not a structural damage report. If box B above is checked, it should be understood that some degree of damage, including hidden damage, may be present. If any questions arise regarding damage indicated by this report, it is recommended that the buyer or any interested parties contact a qualified structural professional to determine the extent of damage and the need for repairs.

Yes No It appears that the structure(s) or a portion thereof may have been previously treated. Visible evidence of possible previous treatment: _____

The inspecting company can give no assurances with regard to work done by other companies. The company that performed the treatment should be contacted for information on treatment and any warranty or service agreement which may be in place.

Section III. Recommendations

- No treatment recommended: (Explain if Box B in Section II is checked) _____
- Recommend treatment for the control of: _____

Section IV. Obstructions and Inaccessible Areas

The following areas of the structure(s) inspected were obstructed or inaccessible:

- Basement _____
- Crawlspace _____
- Main Level _____
- Attic _____
- Garage _____
- Exterior _____
- Porch _____
- Addition _____
- Other _____

The inspector may write out obstructions or use the following optional key:

- | | |
|-------------------------|--|
| 1. Fixed ceiling | 13. Only visual access |
| 2. Suspended ceiling | 14. Cluttered condition |
| 3. Fixed wall covering | 15. Standing water |
| 4. Floor covering | 16. Dense vegetation |
| 5. Insulation | 17. Exterior siding |
| 6. Cabinets or shelving | 18. Window well covers |
| 7. Stored items | 19. Wood pile |
| 8. Furnishings | 20. Snow |
| 9. Appliances | 21. Unsafe conditions |
| 10. No access or entry | 22. Rigid foam board |
| 11. Limited access | 23. Synthetic stucco |
| 12. No access beneath | 24. Duct work, plumbing, and/or wiring |

Section V. Additional Comments and Attachments (these are an integral part of the report)

Attachments _____

Signature of Seller(s) or Owner(s) if refinancing. Seller acknowledges that all information regarding W.D.I. infestation, damage, repair, and treatment history has been disclosed to the buyer.

X

Signature of Buyer. The undersigned hereby acknowledges receipt of a copy of both page 1 and page 2 of this report and understands the information reported.

X

Important Consumer Information Regarding the Scope and Limitations of the Inspection

Please read this entire page as it is part of this report. This report is not a guarantee or warranty as to the absence of wood destroying insects nor is it a structural integrity report. The inspector's training and experience do not qualify the inspector in damage evaluation or any other building construction technology and/or repair.

- 1. About the Inspection:** A visual inspection was conducted in the readily accessible areas of the structure(s) indicated (see Page 1) including attics and crawlspaces which permitted entry during the inspection. The inspection included probing and/or sounding of unobstructed and accessible areas to determine the presence or absence of visual evidence of wood destroying insects. The WDI inspection firm is not responsible to repair any damage or treat any infestation at the structure(s) inspected, except as may be provided by separate contract. Also, wood destroying insect infestation and/or damage may exist in concealed or inaccessible areas. The inspection firm cannot guarantee that any wood destroying insect infestation and/or damage disclosed by this inspection represents all of the wood destroying insect infestation and/or damage which may exist as of the date of the inspection. ***For purposes of this inspection, wood destroying insects include: termites, carpenter ants, carpenter bees, and reinfesting wood boring beetles. This inspection does not include mold, mildew or noninsect wood destroying organisms.*** This report shall be considered invalid for purposes of securing a mortgage and/or settlement of property transfer if not used within ninety (90) days from the date of inspection. **This shall not be construed as a 90-day warranty. There is no warranty, express or implied, related to this report unless disclosed as required by state regulations or a written warranty or service agreement is attached.**
- 2. Treatment Recommendation Guidelines Regarding Subterranean Termites:** FHA and VA require treatment when any active infestation of subterranean termites is found. If signs of subterranean termites — but no activity — are found in a structure that shows no evidence of having been treated for subterranean termites in the past, then a treatment should be recommended. A treatment may also be recommended for a previously treated structure showing evidence of subterranean termites — but no activity — if there is no documentation of a liquid treatment by a licensed pest control company within the previous five years unless the structure is presently under warranty or covered by a service agreement with a licensed pest control company.
- 3. Obstructions and Inaccessible Areas:** No inspection was made in areas which required the breaking apart or into, dismantling, removal of any object, including but not limited to: moldings, floor coverings, wall coverings, siding, fixed ceilings, insulation, furniture, appliances, and/or personal possessions; nor were areas inspected which were obstructed or inaccessible for physical access on the date of inspection. Your inspector may write out inaccessible areas or use the key in Section IV. Crawl spaces, attics, and/or other areas may be deemed inaccessible if the opening to the area is not large enough to provide physical access for the inspector or if a ladder was required for access. Crawl spaces (or portions thereof) may also be deemed inaccessible if there is less than 24 inches of clearance from the bottom of the floor joists to the surface below. If any area which has been reported as inaccessible is made accessible, the inspection company may be contacted for another inspection. An additional fee may apply.
- 4. Consumer Maintenance Advisory Regarding Integrated Pest Management for Prevention of Wood Destroying Insects.** Any structure can be attacked by wood destroying insects. Homeowners should be aware of and try to eliminate conditions which promote insect infestation in and around their structure(s). Factors which may lead to wood destroying insect infestation include: earth to wood contact, foam insulation at foundation in contact with soil, faulty grade, improper drainage, firewood against structure(s), insufficient ventilation, moisture, wood debris in crawlspace, wood mulch or ground cover in contact with the structure, tree branches touching structure(s), landscape timbers and wood decay. Should these or other conditions exist, corrective measures should be taken in order to reduce the chances of infestation of wood destroying insects and the need for treatment.
- 5. Neither the inspecting company nor the inspector has had, presently has, or contemplates having any interest in the property inspected.**

SUGGESTED GUIDELINES FOR COMPLETING THE WOOD DESTROYING INSECT INSPECTION REPORT—NPMA-33 (Version 9/9/04)

Form NPMA-33 MUST be used by wood destroying insect (WDI) inspectors to report the results of WDI inspections for any *HUD/VA guaranteed* property transactions. The NPMA-33 is also typically used for conventional transactions. If a state, through regulation or statute requires the use of a state approved form and excludes the use of all other forms, the state mandated form must be used.

Under generally accepted practices, it is the responsibility of the inspector/inspecting company to inspect for and report on visible evidence of wood destroying insects and of possible previous treatment. Inspected areas of the structure(s) inspected may vary according to local and regulatory requirements and practices.

If the state or state association in which the inspection is conducted has prescribed procedures for inspections, those should be followed in conducting the inspection. The NPMA-33 does not preempt state requirements for inspection practices and reporting. If no state guidance exists, the inspection procedures should be in accordance with NPMA guidance and industry publications and programs.

Before starting the inspection process, inspectors should read and understand the NPMA-33. If completing the form by hand, a fine point pen is recommended.

Section I. General Information

This section is for reporting general information about the location of the inspection and the inspecting company. All boxes in this section must be filled out completely.

Inspection Company, Address, & Phone: Enter the business name, address, and business phone number of the company performing and reporting the results of the inspection.

Company's Business Lic. No.: Enter the business license number of the company conducting the inspection. ***This is the state license to conduct pest control or pest inspection activities.*** In states where no business licenses are issued, enter "*not applicable in this state.*"

Date of Inspection: Enter the date on which the inspection was conducted. If it was done on more than one date, enter all dates that the property was inspected.

Address of Property Inspected: Enter the complete physical address (and mailing address if different from the physical address) of the property. The seller's name and/or buyer's name may be entered here, but is not required.

Inspector's Name, Signature & Certification, Registration, or Lic. #: Print the full name of the inspector who conducted the inspection. The inspector must then also sign the report and enter his/her certification, registration, or license number issued by the state pest control or pesticide control regulatory agency.

Structure(s) Inspected: List all of the structures on the property that are part of the report (for example: "*house and garage*"). Any findings are restricted to visible evidence in, within, or on the structure including the structure itself and areas beneath any portion

of the structure such as crawls, basements, and porches. Areas under eaves and not under any other portion of the structure are not considered in, within, or on the structure. The person ordering the inspection should specify which structures are to be inspected. That information should be relayed exactly to the inspector prior to the inspection. When possible, the buyer or buyer's agent should order the inspection.

Section II. Inspection Findings

In this section, the results of the inspection are reported. If more room is necessary, comments may be noted in **Section V** or by using attachments if such attachments are listed in **Section V**. The inspection reports conditions on the date of the inspection only and no warranty is provided by this report unless accompanied by an attachment and noted in **Section V**.

A. No visible evidence of wood destroying insects was observed.

Check this box if there is absolutely no visible evidence of WDI in, on, or within the structure as defined above. Wood destroying insects for the purpose of this inspection include **termites, carpenter ants, carpenter bees, and reinfesting wood boring beetles**. This box should NOT be checked if there is ANY visible evidence of wood destroying insects.

B. Visible evidence of wood destroying insects was observed as follows:

Check this box if there is ANY visible evidence of WDI observed regardless of extent or age of evidence. If **box B** is checked, at least one of the following boxes must be checked and an explanation, description, and location of the WDI evidence must be provided. More than one of the following boxes can be checked as appropriate.

1. Live Insects; (description and location):

Check this box if live wood destroying insects were found. List the type, and specify the general area(s) where the live insects were found. The areas listed should provide enough detail to direct other inspectors to the general area.

2. Dead insects, insect parts, frass, shelter tubes, exit holes, or staining (description and location):

Check this box if dead insects, insect parts, frass, shelter tubes, exit holes, or staining (carpenter bee droppings or scraped termite tubes) were found. Describe the evidence and specify general area(s) where evidence was found.

3. Damage from wood destroying insects noted in the following area(s):

Check this box and specify the general area(s) where the evidence was noted if visible damage caused by WDI was observed. The inspector is not expected to be a damage expert; damage is nothing more than visible evidence of either current or previous infestation. The inspector is not expected to distinguish between structural and cosmetic damage. The report clearly states "*this is not a structural damage report*". If the inspection company does provide damage evaluation and/or repair as an additional service, a separate contract should be attached and may be noted as an attachment in **Section V**. Note that the next paragraph on the form clearly explains to the buyer and seller that damage, including hidden damage, may be present if **box B** is checked above. Further, if any questions arise regarding damage reported, a qualified structural professional should be contacted. This is to make sure that all parties understand the potential of damage prior to closing and that the inspector is not party to damage evaluation.

It appears that the structure(s) or a portion thereof may have been previously treated. Visible evidence of possible previous treatment:

This section is designed to describe possible previous treatment. Such evidence of a possible previous treatment may include drill marks, termite bait stations in place, dyed wood from a borate treatment, dusted carpenter bee holes, documentation presented to the inspector prior to completion of the report, etc.

Check either the **Yes box** or the **No box** regardless of whether **box A** or **box B** was checked. Enter observed visible evidence of possible previous treatment. If the **NO box** is checked, then no description should be entered on the line. As indicated on the form, the inspector is not expected to give assurances with regard to work done by other companies.

Section III. Recommendations

Based on observations in **Section II**, the lenders, realtors, buyers and sellers are looking to the inspector to make a recommendation as to what corrective measures may be necessary or prudent. The inspector should use his/her knowledge, training and expertise along with careful observation of the structure(s) being inspected when deciding whether or not a treatment should be recommended.

Live insects do not necessarily have to be observed during the inspection for the inspector to recommend a treatment. Examples may include: fresh carpenter ant or powder post beetle frass, carpenter bee staining or signs of subterranean termites with no evidence of previous treatment.

Regarding Subterranean Termite Recommendations

Termite control treatment should be recommended:

- ◆ Whenever live termites are observed (regardless of whether or not the structure has been previously treated).
- ◆ When there is evidence of termites (other than live insects) observed in/on a structure and no evidence of a previous treatment.

A treatment MAY also be recommended for a previously treated structure(s) showing signs of infestation – but no live insects – if there is no treatment documentation provided to the inspector prior to completing the report. Documentation must be a service record of a liquid soil termite treatment within the past five (5) years by a licensed pest control company or proof that the structure(s) is presently covered by a warranty or service contract with a licensed pest control company. The warranty or service agreement may also include a baiting program. If there is no treatment documentation presented to the inspector, then the inspector would recommend treatment for subterranean termites indicating on the report, *“unless there is documentation of a previous liquid treatment within the past five years or unless a service agreement is current”* or similar language. If a baiting system is installed but the inspector does not know whether the contract is current, the inspector MAY recommended a treatment for subterranean termites and should also note *“unless there is a current baiting system service agreement in effect”* or similar language. If any documentation is presented after the report is completed, the inspector should not change the report but rather advise that documentation be provided to the lender or appropriate parties.

It should be understood that these treatment recommendations are suggested guidelines. Every inspection is different and there may be special situations, mitigating factors, or state regulations, which could cause an inspector to make a recommendation that does not follow these general guidelines.

Section IV. Obstructions & Inaccessible Areas

Virtually every property will have some obstructed or inaccessible areas. The typical areas are listed with a key provided on the right side for ease of use. For example, if there were boxes stored against the wall in the basement, the walls were paneled, and there was ceiling tile, the box next to **Basement** would be checked and “1,3,7” would be listed. In addition, or in place of the key, a written description may be entered on the line. If more space is necessary, additional areas may be listed under **Other** or in **Section V**.

Section V. Additional Comments and Attachments

List any additional comments from any section. This may include any pertinent information not previously listed. Service agreement information, if any, should be noted including expiration date. If additional space is necessary, comments may be continued on an attachment and referenced on the **Attachments** line. List **all** attachments in this section. The buyer will then know that there are important attachments to the report.

Signature of Buyer & Seller.

The buyer and seller must sign the report. It is not the inspector's responsibility to obtain these signatures. These should be obtained at closing by the realtor or closing firm. The seller's signature signifies that the seller agrees that all pertinent property history regarding WDI infestation, damage, repair and treatment has been disclosed to the buyer. The buyer signs the form to indicate that they acknowledge receipt of a copy of the report.

Page 2... Important Consumer Information Regarding the Scope and Limitations...

This page contains information for the consumer in order to explain the scope and limitations of the inspection. Inspectors should read and understand all information on **Page 2**. In addition, a maintenance advisory regarding integrated pest management is detailed for the consumer. Both the buyer and seller should agree to any corrective action and responsibility for corrective action. Under no circumstances is the inspector responsible for corrective action unless provided by separate contract. A full understanding of the scope and limitations of the inspection cannot be gained without reading **Page 2**.

1. About the Inspection

This section addresses what WDI pests and general inspection and warranty parameters are covered by the report. It reinforces that mold, mildew, or non-insect pests are not covered by this inspection or report.

2. Treatment Recommendation Guidelines Regarding Subterranean Termites

This section provides additional detail and guidance to the inspector to assist in making the often difficult decision as to when a recommendation for treatment should be made in **Section III**. It provides some of the factors considered by the inspector in his/her decision making process. Much of the language in this section reflects the guidance provided under **Section III** above.

3. Obstructions and Inaccessible Areas

This section provides additional detail to the inspector and customer as to what is commonly considered an area obstructed from or inaccessible to inspection. It provides guidance on completing **Section IV** of the form. This section states that lack of a ladder for access or less than 24" of clearance beneath floor joists in the crawl space are acceptable explanations or inaccessibility to parts of the structure. **Note that neither of these factors are intended to limit the scope or quality of the inspection when the inspector can readily gain access to these areas.**

4. Consumer Maintenance Advisory Regarding Integrated Pest Management for Prevention of Wood Destroying Insects

This section provides suggestions to homeowners about corrective measures, other than treatments, that could be undertaken to reduce the chances of WDI problems in the structure(s).

5. Neither the inspecting company nor the inspector has had, presently has, or contemplates having any interest in the property inspected

This statement means that the inspector is not related in the transaction to the buyer, seller, or the agents involved.

The form and these suggested guidelines are copyrighted and cannot be reproduced or altered in any manner without written consent of NPMA.

Wood Destroying Organisms

If your state or area requires a wood destroying organism report, NPMA has prepared a model of a *Wood Destroying Organism Attachment to the Wood Destroying Insect Inspection Report*. The attachment is designed to report fungus conditions. HUD and VA do NOT require an organism attachment as part of national requirements for HUD and VA loans. Inspectors are free to adopt or alter the model *Wood Destroying Organism Attachment* for specific areas. It is not copyrighted and may be reproduced.

For a free copy of the model attachment, send a self-addressed stamped envelope to NPMA Model WDO Form, 8100 Oak St., Dunn Loring, VA 22027

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Study questions

Chapter 1 - Inspections and Equipment

1. If you remove the door sill plate to examine the slab and *do not* see a seam that represents an expansion joint, the house is built on which kind of slab?
 - A. Floating
 - B. Suspended
 - C. Monolithic
 - D. Uniform
2. The inspection process should always begin by
 - A. Obtaining as much information from the client as possible
 - B. Measuring the exterior of the structure
 - C. Diagramming the dimensions of the structure
 - D. Locating permanent water sources near the structure
3. Which of the following tools is *not* normally used when making an inspection for wood-destroying organisms?
 - A. Hammer
 - B. Flashlight
 - C. Ladder
 - D. Moisture meter
 - E. Screwdriver or probe
4. Only about 35 percent of an average home is accessible for inspection.
 - A. True
 - B. False
5. Which of the following common routes of entry is not found in slab homes?
 - A. Bath trap
 - B. Cracks and crevices around plumbing penetrations
 - C. Expansion joints
 - D. Stair stringers embedded in concrete
6. Termites can infest a home by coming through a single crack in the foundation.
 - A. True
 - B. False
7. In normal construction methods, there is an expansion joint between the fireplace and the slab.
 - A. True
 - B. False
8. The guideline for distance between the soil and the sill plate around the perimeter of a home is how many inches?
 - A. Eight
 - B. Six
 - C. Four
 - D. Two
9. You should specifically list on your inspection sheet any areas of the home that are not accessible to visual inspection.
 - A. True
 - B. False
10. You should calibrate your equipment at monthly intervals during the year.
 - A. True
 - B. False
11. You do not need to worry much about dusts being moved to nontarget areas because the particles are so large that they stay in place.
 - A. True
 - B. False
12. Which of the following forms of pesticides is not commonly used to control wood-destroying organisms?
 - A. Liquids
 - B. Baits
 - C. Fumigants
 - D. Granules

2

TERMITES

The order Isoptera is composed of termites. They are recognized by unique physical features and their habit of living together in groups called colonies. Colonies of soft, creamy-white, wingless individuals are found in mounds, pieces of wood, or underground. They are more common in tropical areas because of high humidity, warm temperatures, and moist soil there. There are more than 2,500 species known worldwide, but only about 45 species occur in the United States. Most of the U.S. species inhabit the southernmost tier of states and states that border the oceans. A few species inhabit interior and northern regions. Within the Midwestern states, only four species are found, and the risk of infestation varies widely within this region (Figure 2-1).

Termites are social insects. Other social insects include ants, bees, and wasps. Social insects live in large groups, share a nest, and divide the biological roles of reproduction, feeding, nesting, and defense among distinct forms called castes. The soldier caste is responsible for defense, the worker caste is responsible for maintaining the nest and feeding the colony, and queens and kings are responsible for reproduction. A few other castes also exist, including larvae and nymphs. If the social system of a termite colony is destroyed, or if a termite is separated from its colony, they are not able to perform the functions needed for survival and reproduction.

Termites feed on plant material and convert it into humus. Humus enriches the soil and provides nutrients for living plants. Plant materials are made up of a complex sugar molecule called cellulose that termites use as a food source. However, termites cannot digest cellulose themselves. Digestion of cellulose depends on microorganisms that live in the termite gut. These microorganisms break down cellulose and release the nutrients termites need. When termites invade buildings to feed on wood or other cellulose materials used in construction, they cause economic damage.

Termites that cause damage to buildings and other structures in the United States are normally of two types: subterranean termites and drywood termites. Drywood termites belong to the family Kalotermitidae



Figure 2-1 Distribution of subterranean and drywood termites in the United States. Most U.S. species of termites inhabit the southernmost tier of states and states that border the ocean. Within the upper Midwest region (inset) the risk of infestation from subterranean termites varies widely from higher risk in the south and east to relatively little risk to the north and west.

and subterranean termites belong to the family Rhinotermitidae. Because of their widespread distribution, subterranean termites are responsible for most of the termite damage in the United States. All the termite species in the upper Midwest are subterranean termites. Approximately \$2.5 billion are spent annually in the United States to control subterranean termite infestations and repair damage they cause.

SUBTERRANEAN TERMITES

Identification

The house-infesting termites in the upper Midwest belong to the family Rhinotermitidae and the genus *Reticulitermes*. Subterranean termite colonies are located in soil and wood that is in contact with soil. They also build shelter tubes across open areas to infest wood that is not in direct contact with soil (Figure 2-2). Tunnels in infested wood always contain soil mixed with fecal material.

Subterranean termites can be identified by looking at the soldiers or reproductive castes. *Reticulitermes*



Figure 2-2. Subterranean termite shelter tube on a foundation wall. These protective tubes made of soil and fecal material are built across open areas and allow subterranean termites to leave the soil and infest wood above the ground.

soldiers have enlarged, rectangular, reddish brown heads with long, swordlike mandibles that are directed forward. The sides of their heads are nearly parallel and the head is longer than it is wide. Their mandibles lack teeth along the edges (Figure 2-3). *Reticulitermes* reproductives have darkened bodies that vary in color from chestnut brown to black. During the swarm stage, reproductives have wings that are silvery white in color. There are two veins along the front of the wing. One dark, thickened vein runs along the front edge and a second dark, thick vein runs parallel behind it (Figure 2-4). The veins in the

rest of the wing are very faint.

There may be some light branching cross veins and faint hairs on the wing, but they usually have color only in the area around the base of the wing.

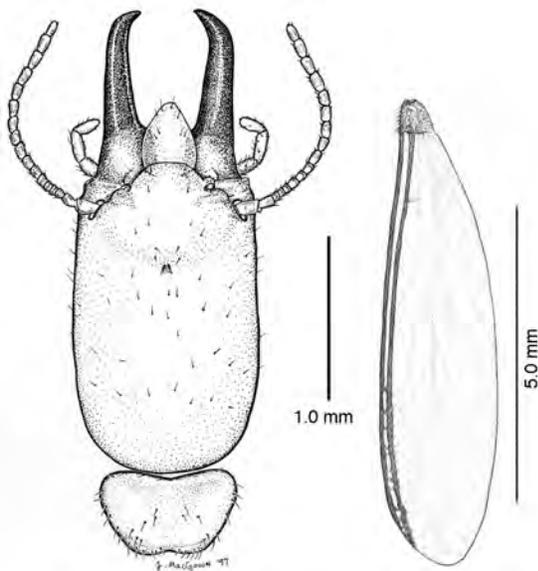


Figure 2-3 (left). Subterranean termite soldier head. These soldiers are recognized by their enlarged, rectangular, reddish brown heads with long, swordlike mandibles that lack teeth along the edges.

Figure 2-4 (right). Subterranean termite swarmer wing. Subterranean termite wings are recognized by the two parallel, dark, thickened veins that run along the front edge of the wing. Veins in the rest of the wing are very faint.

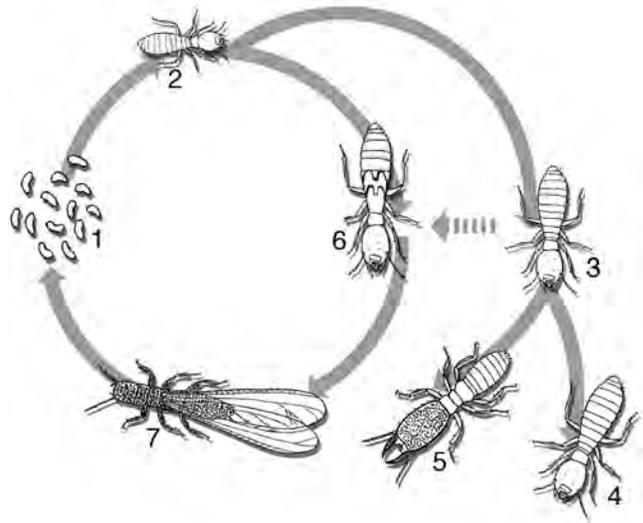


Figure 2-5. Simplified life cycle of subterranean termites. After hatching, termites pass through many, but not all of the stages shown here. In general, eggs (1) hatch into larvae (2) that either develop down the worker (3, 4) and soldier (5) pathway, or the nymph (6) to swarmer (7) pathway.

Biology and behavior

Subterranean termite castes include eggs, larvae, workers, soldiers, nymphs and reproductives. The pathways of development between these castes are shown in Figure 2-5.

Reproductives

The colony contains at least one functional king and queen. They cooperate to produce fertilized eggs. Two types of kings and queens can be found in termite colonies. They are primary reproductives or supplemental reproductives. Primary reproductives are the initial founders of a new termite colony. These kings and queens reached the winged stage, flew from their parent colony, and started a new colony. Supplemental reproductives do not found new colonies. These kings and queens develop within the colony of their origin without ever reaching the winged stage. This occurs only when one or both of the primary reproductives have been separated from the colony or when they have died or no longer produce eggs.

Primary reproductives pass through a winged stage called a swarmer (Figure 2-6). Swarmers are dark in color and have fully developed wings. Termite swarmers may superficially resemble ant swarmers, but the two are easily distinguished from one another (Figure 2-7). Termite swarmers emerge from mature colonies at a certain time of year. Each *Reticulitermes* species has its own 6- to 8-week period when swarms are likely to occur. In the Midwest, *Reticulitermes flavipes* and *Reticulitermes virginicus* swarm from April until June but *Reticulitermes hageni* swarms during August and September. *Reticulitermes* swarms usually

Chris Jung

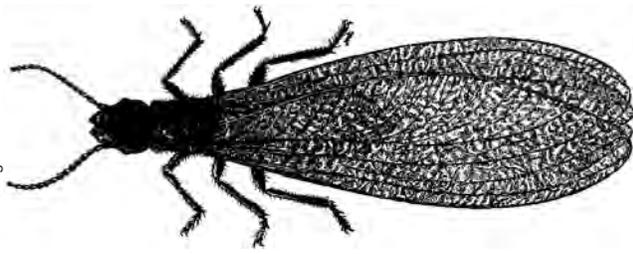


Figure 2-6. Subterranean termite swarmer. Swarmers are dark in color and have fully developed wings.

occur on warm, sunny days following rain. They do not swarm at night.

After flying away from the parent colony, termite swarmers shed their wings. Females call males using chemical signals. When a male detects a female and locates her, she begins searching for a nest site. The male follows her by touching the sides of her body with his antennae. The pair starts a new nest by first constructing a protective cell called a copularium in the soil — usually adjacent to wood. Once the copularium is finished, mating occurs and egg production begins. When these eggs hatch, a simple family unit is formed that constitutes the beginning of a new colony.

Eggs

Reticulitermes queens lay clusters of eggs. A primary queen can lay more eggs than a supplemental queen. However, multiple supplemental queens usually replace a single primary queen, so their combined egg production is more than a primary queen. The eggs look like small, translucent jelly-beans. They are kept clean by other members of the colony to protect them from bacteria, fungi and other microorganisms in the soil. The primary king and queen care for the first batch of eggs themselves and then raise the first larvae that hatch by feeding them regurgitated plant materials and feces.

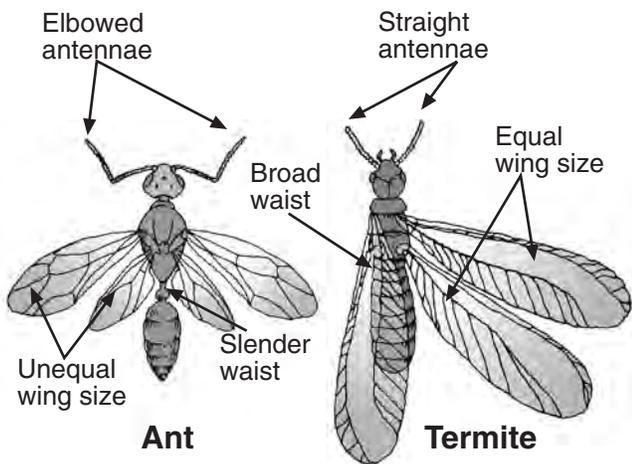


Figure 2-7. Comparison between termite and ant swarmer. Termite swarmers have equal-sized wings, a broad waist and antennae without an elbow.

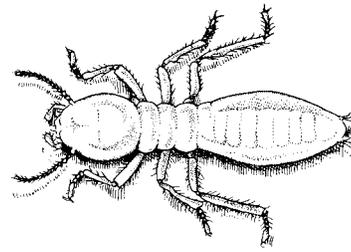


Figure 2-8. Subterranean termite larva. This caste is much smaller than other castes, no hardened body parts and very little coloration.

Larvae

Young termites that hatch from eggs are called larvae (Figure 2-8). They shed their exoskeleton once during this stage. Larvae are smaller than other castes, have soft, white head capsules and mouthparts, and an absence of coloration. They perform little or no work in the colony and are dependent on other termites to feed them a liquid diet. Larvae have the potential to become any other caste within the colony.

Trophallaxis is the term that refers to food sharing in termite colonies. The exchange of liquid food between nestmates is important for nutrition, communication and caste development. Two types of liquid food are shared. One type is called stomodeal food. It consists of regurgitated fragments of food and saliva that are transferred mouth-to-mouth between termites. Another type is called proctodeal food. Proctodeal food comes from the anus and contains anal secretions, fatty acids, microorganisms and chemicals called pheromones. Pheromones are chemical messages. Pheromones in proctodeal food function in directing the growth and development of larvae into certain castes.

When larvae hatch they do not possess the microorganisms that are critical for digesting cellulose. They must obtain them from proctodeal food that the primary king and queen provide. Several species of protozoa are found in the gut of *Reticulitermes*. They perform fermentation of the cellulose that releases fatty acids. The fatty acids are absorbed by the termite after fermentation. The types of protozoa and the relative amounts of each type vary between termite species.

Workers

Workers are the most common caste in a colony. Usually over 90 percent of the termites belong to this caste. This caste has no distinctive physical features, but is characterized by light-brown round heads without eyes. They have small dark brown mandibles. Their bodies are wingless, creamy-white and soft (Figure 2-9). Workers can develop into soldiers or nymphs under the right conditions.

In *Reticulitermes*, workers pass through several growth stages before maturity. They mature within a few months and live from one to two years. After reaching maturity, workers continue to shed their exoskel-

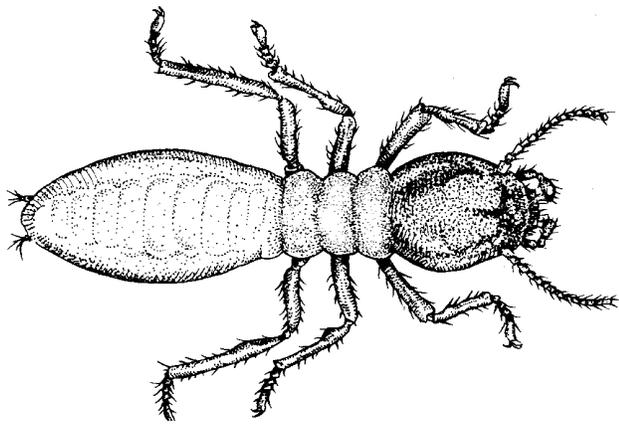


Figure 2-9. Subterranean termite worker. This is the most common caste in the colony. Workers are recognized by light-brown, round heads without eyes and wingless, creamy-white, soft bodies.

etons (molt) periodically throughout the remainder of their lives with no increase in size. Workers are responsible for feeding themselves and all other caste members, for enlarging the nest to accommodate the growing colony, for grooming colony members and for assisting soldiers in defense when under attack. All worker stages are involved in these functions.

Nest-building consists of tunneling in the soil. Tunneling is critical for colony survival because it provides shelter for the colony and brings the colony into contact with new food sources. The nest is a network of tunnels extending out through the soil and into wood associated with soil. Tunneling occurs in soils that have consistently favorable temperature and moisture conditions. Large fluctuations in soil temperature or moisture make an area less suitable for termite activity. Termite workers also follow linear objects in the soil that serve as guidelines such as roots, pipes, wires foundations.

Tunnels may also extend above ground through small tubes made of soil and fecal matter. These mud tubes provide shelter from the open air and protection from their enemies. Subterranean termites are very susceptible to drying out when exposed to open air, so tunnel networks must be repaired and maintained in good condition. Workers continually search and add new food sources to their tunnel networks. When food is located, it is consumed first by workers then shared with other castes through trophallaxis.

When they have a choice, workers can be finicky in their feeding habits. In general, they prefer to feed on softer wood. In a single piece of wood, they preferentially feed on sapwood over heartwood and softer spring rings over less soft summer rings. Feeding may be stimulated by chemicals produced when brown rot fungi feed on wood. These breakdown products are generally attractive to termite workers, while breakdown products from white rot fungi can actually be repellent. When they have no choice, workers will be opportunistic in their feeding. They are capable of

feeding on a wide variety of woods, including redwood, cedar and cypress. They have even been observed feeding on peanuts, apples, strawberries and pansies.

Soldiers

Only about 1–2 percent of the termites in a colony belong to the soldier caste (Figure 2-10). In *Reticulitermes* there are male and female soldiers. Soldiers are considered adults because they do not develop into any other caste. Soldiers are responsible for colony defense. They have enlarged heads and mandibles, which they use to sound alarms, block tunnels, and attack invading enemies (Figure 2-11) inside tunnels. Because of their enlarged heads and modified mouthparts, soldiers rely on workers to feed them.

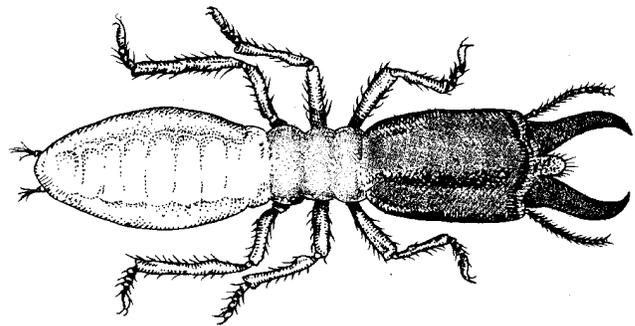


Figure 2-10 Subterranean termite soldier. They have distinctively large, rectangular, reddish brown heads with long, swordlike mandibles.

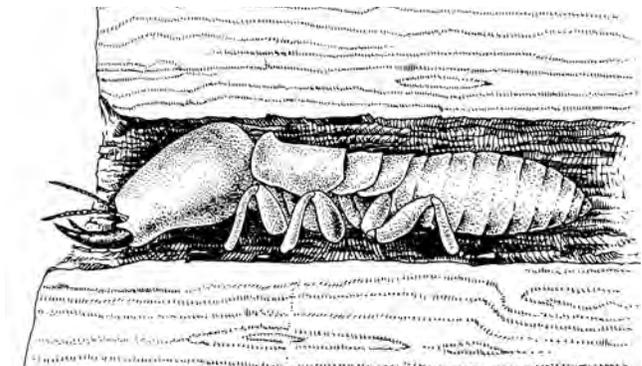


Figure 2-11. Subterranean termite soldier in wood. When intruders are detected soldiers block, snap, and lunge at them inside tunnels. They make alarm signals by tapping their heads on the walls of the tunnel which alerts the colony and recruits reinforcements to the area.

Termite colonies have a chemical signature that distinguishes them from other colonies. This signature is the result of chemicals in their surroundings, food sources, and pheromone signals that adhere to their exoskeleton. These chemical signatures allow termites to identify termites from another colony or other invaders. Aggression is common between termite colonies when they come into contact with one another. The level of aggression varies between different colonies and species, but in general, aggression is lower for *Reticulitermes flavipes* than for other species in this genus.

When an intruder is detected, soldiers block tunnels, snap and lunge at intruders inside tunnels, and initiate alarm signals to alert workers in the colony. Snapping and lunging in tunnels can immobilize or kill intruders, but additional soldiers and workers are recruited by means of alarm signals. Soldiers make alarm signals by quivering and tapping their heads on the bottom of the tunnel. The tapping creates vibrations that workers detect in the substrate by a specialized organ on their front legs called the subgenual organ. Termites cannot detect airborne sounds. After workers receive the alarm signal, they quiver, enter an excited state, make zigzag movements and bump heads with their nestmates. This puts the colony in a state of alert and recruits reinforcements to the area where intruders are detected.

Nymphs

Termites in this caste are preparing to molt into fully winged termites and leave the nest to start new colonies (Figure 2-12). If isolated during this stage, individual nymphs can become capable of reproduction. Nymphs that go through this change are called secondary reproductives. Secondary reproductives are relatively common in mature colonies.

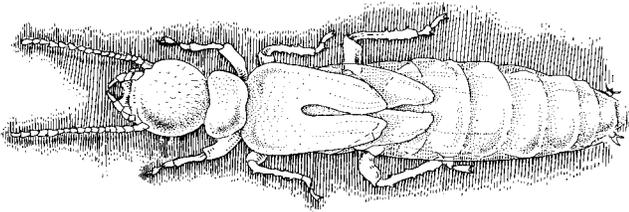


Figure 2-12. Subterranean termite nymph. This caste is recognized by its slender appearance and the presence of wing pads above the legs. These pads eventually develop into wings in the swarmer.

Feeding and infestation

Subterranean termites invade homes from the soil around and beneath the structure. Infestations occur when subterranean termite workers locate structural wood in contact with soil or when termites build shelter tubes from the soil across foundation walls and into structural wood. Subterranean termites may also gain access through cracks in the slab or seams where plumbing and electrical lines penetrate the concrete. Foundations made of hollow blocks, or of masonry and rock provide several avenues for termites to gain undetected access to wooden parts of the structure. Once inside, subterranean termite colonies maintain access to the soil around or under a home through their shelter tubes. The soil provides them with necessary moisture to remain healthy. However, if a source of moisture exists within the wood, such as a water leak from a pipe or roof, contact with the soil is not necessary.

Subterranean termites do not cause significant damage over a period of days or weeks. It typically takes several months or years of feeding for damage to be significant. They prefer to feed on the soft grain of the wood. In severely infested wood, only the hard grain and a thin outer shell remain. Termites intentionally remain hidden within infested wood, preferring not to be exposed to the outside environment. This makes it very difficult to locate infested wood in a structure. An infested timber can look perfectly normal on the outside, even when riddled with termite galleries on the inside.

Subterranean termite damage looks distinctive. An active infestation is recognized by the presence of live termites and a fecal-soil mixture within the tunnels. This soil mixture is brought into the tunnels to help maintain humidity. In active infestations, this soil looks moist. In old damage, the soil in the tunnels looks dry. It is impossible to determine how old termite damage is by looking at the infested wood. A survey of the extent of damaged wood throughout a home is generally more helpful in determining the length of time associated with an infestation. In general, large areas of damaged wood indicate longer-term infestations, while smaller areas of damage may indicate less time since infestation.

To check for subterranean termites, probe any wood near the foundation or soil with a sharp screwdriver. Pay close attention to sill plates, header joists, ends of floor joists, bases of wall studs, and flooring. Termite-damaged wood offers little resistance to the probe. The presence of earthen shelter tubes on a foundation wall or wood is also evidence of infestation. The presence of large numbers of swarmers inside a structure is a sure sign the structure is infested. If you find damage, there is no need to apply control measures immediately. Termites work slowly, and a few weeks of delay are of little consequence.

Prevention and control

Current termite treatment strategies use either a chemical barrier placed in the soil around the structure to prevent termites from moving between the soil and structural wood or chemical baits that are placed in termite foraging areas to kill colonies living around and inside structures. In addition, post-construction control strategies can involve modifying the structure to create mechanical barriers.

Building construction

Proper control of subterranean termites requires a basic understanding of building construction. Identifying the construction type is a key to any treatment strategy because it helps you determine where subterranean termites may be entering the structure. In the United States, standard construction methods

are designed to offer some protection against subterranean termite infestation by keeping the edible wooden parts of the structure off of the ground and the inedible concrete, rock, or block foundations in contact with the soil. However, subterranean termites can cross foundations and gain access to the wooden parts of a structure through expansion joints, cracks or other small openings.

The most common construction types are slab, basement and crawl space construction. Sometimes they are used together in the same structure. Each has its own areas of susceptibility to subterranean termite infestation. You need to be able to identify each construction type and formulate a treatment plan that addresses the inherent termite entry points that it possesses.

Slabs. Slab foundation walls are either solid poured concrete or hollow block, resting on a solid concrete footer that is wider in width than the wall and usually situated below the frost line. When a hollow block foundation wall is used, sand, gravel, cinders, clay or native soil are used to fill the resulting spaces on the interior and exterior of the blocks. If not tamped down they settle, leaving a void under the slab. Often, a minimum of mortar is applied to seal the blocks together, leaving open joints that allow termite entry to the inside of the block. A waterproofing membrane, usually polyethylene film is laid between the fill and the slab, extending across the foundation wall. Resting on top of the slab system is the bottom-most wooden piece of the house frame, the sill plate. Three types of slab construction are commonly used: monolithic, supported and floating.

Monolithic. The monolithic slab, used in residences, barracks, and in relatively dry climates, is a solid unit of concrete that forms the slab and foundation wall (Figure 2-13a). If a footing is not found when probing down parallel to the foundation wall, the slab is monolithic. It is thickened to act as its own footing, and reinforced with internal steel rods (impel rods). The unit is poured in one continuous operation, but still has openings cut into the slab for various supply and waste plumbing lines and others hidden in wall voids for toilets, washing machines and water heaters. When larger than 4,000 feet, slabs are often divided with expansion joints. These expansion joints can serve as subterranean termite entry points. Settlement cracks may also serve as subterranean termite entry points. These cracks may occur in monolithic slabs at the curvature of the wall and slab portions and under load-bearing walls and fireplaces. Post tensioning systems are being used more frequently now to reinforce the foundation wall of the monolithic slab, producing smaller settlement cracks, which reduce but do not eliminate termite entry.

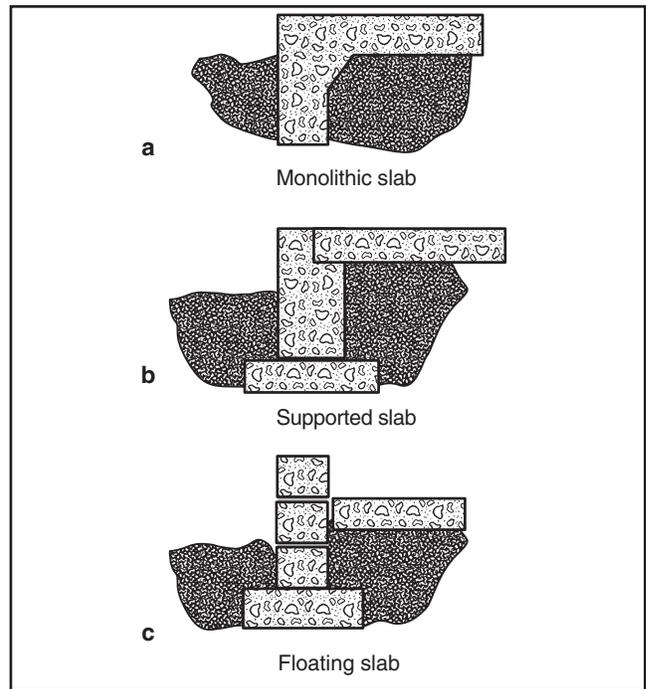


Figure 2-13. Three common types of slab foundations. A monolithic slab (a) is a single, solid unit of concrete that forms both the slab and foundation walls. A supported slab (b) partially or fully rests on the concrete foundation walls. A floating slab (c) is a sheet of concrete poured directly on soil that butts up to separate slab foundation walls.

Post tensioning can be recognized by evenly spaced round holes on the slab wall exterior.

Supported. The edges of a supported concrete slab partially or fully rest on a concrete foundation wall, which in turn is poured on a concrete grade beam or posts (see Figure 2-13b). You can remove the threshold plate under an exterior door to determine whether a slab is supported. If there is a seam or crack in the center of the doorway, the slab is supported. These seams around the perimeter of the structure are areas where subterranean termites can enter the structure and go directly into the wall, often undetected. Supported slabs also have openings in the slab around various supply and waste plumbing lines for bathtubs, toilets, washing machines and water heaters. Settlement cracks that occur in supported slabs can become entryways for subterranean termites.

Floating. The floating slab is a sheet of concrete poured directly on soil (see Figure 2-13c). These slabs are used extensively in commercial, industrial and warehouse construction. The perimeter butts up to a separate slab foundation wall, leaving an opening or seam between the two edges. To determine whether a slab is floating, remove the threshold plate under an exterior door and examine this seam. If the seam is even with the interior wall, the slab is floating. These seams are susceptible to subterranean termite invasion. Settlement

cracks may also occur in floating slabs and provide additional entry points for subterranean termites. Most basements are similar to floating slabs and have similar susceptibilities to termite invasion.

Crawl spaces. Crawl space foundation walls may be constructed of poured concrete, concrete block, stone, brick or any combination of any of these materials. Part of the foundation wall rests on the footer underground and extends above ground several inches to a foot or more. Additional support columns of steel or concrete called piers are often used to support the long floor joists. This leaves a space below the floor joists and the soil surface. The sill plates are anchor bolted to the piers, above which there are beams or girders that offer additional support to the floor joists.

The foundation wall and support columns are typically made of concrete or steel. They offer access to all of the wooden underpinnings of the structure when subterranean termites build mud tubes up the outside of the columns. In addition, termites may find entry into the inside of hollow block columns through a cracked footer where they move undetected upward to the structure. Older structures built upon stone or brick foundations that were common in the eastern, Midwestern and southern United States create difficult termite treatment conditions because of the irregular voids that occur within and between foundation mortar joints.

Crawl spaces need proper ventilation to prevent dampness that is conducive to subterranean termites and decay organisms. In some instances, the crawl space may also double as a return air plenum for the heating or air conditioning system.

Conventional soil treatments

Equipment. There is specialized equipment associated with making a conventional soil termiticide application. The basic equipment needed to prepare and apply termiticides around structures is discussed below.

Chemical tank. A large, fiberglass chemical tank is usually mounted in the bed of a standard pickup truck on two metal runners that are connected to a metal framework. A baffle inside the tank keeps the liquid from sloshing around when the vehicle is moving. Tanks usually have a see-through window and markings on the side that are used to determine the amount of termiticide in the tank. The tank can be drained through a bottom valve, which should be tightly closed when there is chemical in the tank.

An electric or gasoline motor, which operates a pump, is also attached to the framework. When it is running, the pump moves the chemical from the tank through a hose. At the end of the hose is a

fitting that allows you to attach a treatment rod. The hose is connected to the pump by way of a bypass valve, which allows termiticide to be pumped back into the tank when it is not moving through the hose.

Measuring stick. A 100-gallon measuring stick, with 5-gallon increments, can be inserted into the tank, removed, and read as if checking the oil in a car. It is important to keep the stick vertical for accuracy.

Drill. Two types of drills are used in termite work. A small hammer-drill is used for drilling into brick veneer, brick foundations or hollow block walls. The large drill also acts as a hammer and is designed to drill through concrete slabs and walls. The diameter of the drill bit must be large enough to allow you to insert the treatment rod and inject termiticide below the slab.

Cement. Hydraulic cement hardens and expands to create a tight fit when it dries. It is used to fill drill holes in concrete. A cork or plastic plug is inserted into each drill hole and pushed down 2 to 3 inches before placing cement in the holes. When mixed to a thick consistency and hand-formed before being placed in drill holes, this cement will set in 3 to 5 minutes to seal out water for the life of the structure. A trowel is used to apply the cement and smooth over plug holes.

Water hose and backflow preventer. A 50-foot hose and backflow preventer are used to fill the chemical tank at the customer's home when needed. You should never use the customer's hose to fill your termiticide tank because of the risk of contamination.

Spray container. Bath traps are normally treated with a smaller, portable sprayer. The needle type nozzle on a small spray container also allows you to apply termiticide into the small cracks and crevices around plumbing penetrations in the concrete slab.

Spill cleanup kit. You should have a kit containing items that are readily available for containment and cleanup of spills. Some common things in this kit include: soak-up compounds (e.g., kitty litter), all-purpose detergent, rubber gloves, assorted scrub brushes, plastic garbage bags, paper towels and a plastic scrub bucket.

Other items. Other items to have with you when using termiticides include a first aid kit, soap, copies of the termiticide label, material safety data sheet (MSDS) information, product literature, personal protective equipment and emergency phone numbers.

Site preparation. You must prepare areas around the home to be treated before mixing or applying termiticide. This ensures that mixed termiticide will be in your chemical tank for a minimal amount of time.

Cleaning. Clear all cellulose debris from inside the crawl space and areas adjacent to the foundation, then remove all existing termite tubes from the foundation.

Digging and drilling. Prepare for trenching and rodding by digging a trench around the entire exterior perimeter of the structure. The trench should be about six inches wide and angled toward the foundation and top of the footing to a depth of 6 to 8 inches. Prepare for sub-slab injecting by drilling holes through concrete slabs inside the structure and through concrete patios, driveways, porches, and sidewalks outside along the edge of the foundation. Drill holes should be approximately 12 inches apart and large enough for the treatment rod to go through them.

Calculating the amount of termiticide. Once a trench is dug and the concrete is drilled, you can calculate the amount of termiticide you will need. The standard treatment rate for soil termiticide applications is 4 gallons of mixed termiticide per 10 linear feet of treatment zone, per foot of depth. To calculate the amount of termiticide needed for a treatment, the linear feet of the trench must be measured then multiplied by the depth in feet. For slab and crawl space homes, assume that the footer is approximately one foot deep around the entire perimeter. For walkout basement homes, the depth to the footer varies. In this case, you measure the distance along each side of the structure and multiply by the depth to the footer along that side of the structure, then add up all the sides to get a total. On the side of the basement where the distance to the footer is greater than 4 feet, your treatment only needs to extend down 4 feet, so the maximum multiplier for depth, even on a basement foundation wall, would be four.

Interior areas where the slab is going to be drilled and treated should also be measured and added to the length of the outside trench. These areas are also treated at the rate of 4 gallons per 10 linear feet. Other treatment areas such as around bath traps, drains, and plumbing penetrations are usually adjusted to three to 5 gallons of termiticide per area. Hollow block wall treatments are adjusted to a lower application rate of 2 gallons of finished termiticide per 10 linear feet. Add the total exterior treatment area and interior treatment area calculations together for the total amount of termiticide needed.

Mixing. You should always follow mixing directions on the label and wear goggles and gloves. Here are some helpful hints for mixing termiticide uniformly in the spray tank:

1. Fill tank $\frac{1}{4}$ to $\frac{1}{3}$ with water.
2. Start the pump and place the end of the treating tool into the tank to allow circulation through the hose.
3. Add the appropriate amount of termiticide.
4. Add the remaining water.
5. Let the pump run and allow recirculation through the hose for 2 to 3 minutes.

While filling the chemical tank, it is important to have a backflow preventer attached to the water spigot. This prevents a sudden drop in water pressure that could suck the contents of the chemical tank backward into the water hose and contaminate the water supply. The hose should never be dropped into the liquid in the tank and must always be held above the fill line when adding water to the tank.

New foaming agents have been developed to help create more uniform, unbroken soil barriers. Foam is able to expand and fill void spaces created below the slab where soil has settled. Foam can be mixed with existing termiticides without diminishing their effectiveness. Dilution rates for foam applications and conventional liquid termiticides differ when used in combination, but these differences are clearly outlined on the product labels. In general, 3 gallons of conventional liquid per 10 linear feet are mixed with 1 gallon of foam per 10 linear feet to create a finished product.

Calibration. Calibration is the process of establishing and measuring the amount of termiticide being applied by a sprayer during a specified time interval. It is critical to know how much termiticide is coming out of your equipment per unit of time (flow rate) in order to deliver the legal amount to a trench or drill holes. The process of calibrating equipment is simple and should be done each time you use a spray pump.

Calibration is a matter of determining flow rate. Flow rates are expressed as volume of liquid per unit of time and are influenced by pressure. To properly calibrate your equipment, a pressure gauge is necessary and you must calibrate at the pressure recommended on the label (normally 20 to 25 psi). Calibrate with the tip you use during application because flow rates change for different tips. Calibration should also be done using water instead of finished pesticide. In most situations, the addition of pesticide to water does not significantly change the application rate.

Since the standard rate of termiticide application is expressed as 4 gallons of liquid per 10 linear feet (per foot of depth), you need to know how long it takes your spray pump to apply one gallon of liquid. To calcu-

late flow rate, set the pressure on your pump to the recommended pressure (20 to 25 psi) and dispense liquid into a marked bucket while using a stopwatch to determine the length of time (in seconds) it takes to dispense one gallon. Multiply the time to dispense one gallon by four to know how much time you should take to treat a 10-foot trench. For example, if during calibration you determined that your flow rate is 50 seconds to dispense one gallon, you multiply by four to determine that you need to spend 200 seconds or 3 minutes 20 seconds (200 seconds/60 seconds per minute) to dispense 4 gallons. This is the amount of time you should spend treating each 10 linear feet. When it is necessary to treat down to a footer that is deeper than one foot, you multiply the number of seconds needed to treat 10 linear feet by the depth (in feet) to the footer. In this example, if we were treating down 3 feet in depth, you would multiply 200 seconds by 3 to determine that you should spend 600 seconds, or 10 minutes, for each 10 linear feet.

If you want to know how much time you should spend treating individual drill holes (spaced 1 foot apart), you multiply the time to dispense one gallon by four, then divide by 10 (the number of holes). With a flow rate of one gallon per 50 seconds, you multiply by four to get 200 seconds, then divide by 10 (the number of drill holes per 10 feet) to get 20 seconds per hole.

Soil termicide chemistry. Subterranean termites are able to detect and respond behaviorally to chemical cues in the soil environment. Some of the chemical cues they respond to are the active ingredients contained in termiticides. Termites detect and are repelled by the residues of some termiticide active ingredients while they do not detect, or they detect but are not repelled by, the active ingredients in other termiticides. A termiticide is categorized as repellent if termites do not tunnel into soil treated with it. A termiticide is categorized as nonrepellent if termites tunnel into soil treated with it. These determinations are easily made using bioassays where termites are placed in tubes containing different types of treated soil and the amount of tunneling is observed.

In a particular situation, the choice to use a repellent or nonrepellent termiticide is one of the most critical choices in determining whether successful subterranean termite control is achieved. It is important to understand the advantages, disadvantages, and situations where repellents and nonrepellents can be used with the greatest chance for success.

Repellents — Several repellent termiticides are available. The active ingredients in these termiticides are all pyrethroids. Pyrethroids are man-made chemicals similar in structure to the natural pyrethrum produced by flowers of chrysanthemum. They are fast-acting nerve poisons that have high toxicity to

insects and low toxicity to mammals. Pyrethroids are common in over-the-counter insecticides. Pyrethroid termiticides are very repellent to termites, inasmuch that they avoid coming into contact with treated soil. Repellent termiticide products and their active ingredients are as follows:

1. Dragnet (permethrin)
2. Cynoff (cypermethrin)
3. Talstar (bifenthrin)
4. Demon (cypermethrin)
5. Prelude (permethrin)

Repellent termiticides have advantages and disadvantages. They are some of the least expensive and longest lasting termiticides that are available on the market. However, because of their repellency, they are also the most prone to re-treatment. The reasons for this are the inherent difficulty that exists in applying a uniformly treated soil barrier around an already-existing structure, and the behavioral response of termites to repellent soils.

When termites encounter repellent soil, they do not tunnel into it and they do not die. Instead, they stay alive and change their direction of tunneling. Often their tunnels bounce along the edges of the repellent soil. Eventually, they encounter untreated gaps in the treatment zone and move through these gaps into the structure. Despite your best efforts, small gaps of untreated soil will still exist around an existing structure following treatment. Several underground obstacles such as plumbing lines and rocks can be responsible for blocking the flow of termiticide in the soil during treatments. These objects create treatment “shadows” where untreated soil remains in the treatment zone.

Repellent termiticides are most effective when used during pre-construction treatments. High volumes of termiticide are required for pretreatments and the low cost of repellent termiticides makes them desirable. They are also some of the most long-lasting termiticides when applied under slabs. They continue to provide repellency at very low concentrations in the soil. Finally, the likelihood of gaps in a pretreatment zone is much lower than in a post-construction treatment zone because the termiticide is applied more uniformly by downward soaking prior to pouring the foundation. Repellent termiticides are not recommended for post-construction treatments because of the likelihood of gaps in the treatment zone. Even with trenching and flooding the trench, there are openings that will be exploited.

Nonrepellents — Relatively few nonrepellent termiticides are available. The active ingredients in them are nerve poisons, but they have unique ways of affecting the nerves and are slow-acting. Subterranean termites readily tunnel into soil treated with these active ingredients and die from their effects. The two

nonrepellent termiticides that are currently available and their active ingredients are:

1. Premise (imidicloprid)
2. Termidor (fipronil)

Nonrepellent termiticides are more expensive and may not last as long as some repellent termiticides. However, they have advantages and are the best choice for post-construction termite control. Subterranean termites tunnel into soil treated with these active ingredients and die after this exposure. In addition, since these active ingredients work slowly, termites exposed to them continue to interact with their nestmates before they die. These interactions allow the active ingredient to be transferred from one termite to another within the colony. As a result, termites in the colony can pick up a lethal dose and die without ever having come into contact with the treated soil barrier.

Nonrepellent termiticides are very effective for both pre- and post-construction treatments. They are especially advantageous where trenching, drilling and rodding must be done. When using these techniques, gaps are more likely to exist in the treated zone. However, these gaps are not as likely to be found with nonrepellents because termites don't have the chance to bounce along the treated zone. Their tunnels immediately enter treated soil without changing direction, so unless they go through an untreated gap perfectly the very first time, they become exposed to the active ingredient, transfer it to their nestmates, and then die.

Termiticide application

Soil treatments involve applying liquid termiticides to the soil under and adjacent to a foundation (Figure 2-14). This forms a chemical barrier against

termite entry. Because only 1/64 inch is sufficient for termites to gain access to a structure it is important to identify and protect all potential entry points. Pre- and post-construction termite treatment instructions are given on each termiticide label. These instructions should be followed closely.

Pre-construction treatments

Preventative soil treatments for subterranean termites are commonly referred to as "pretreats." Relatively few structures built in the upper Midwest are pretreated against termite infestation during the construction process. However, it is important to understand the procedures in the event that a homeowner or contractor contacts you and requests this service.

A pretreat is intended to create a uniform barrier of termiticide between termites in the soil and wooden components of the building. It includes structures built adjacent to the foundation, such as porches and patios. To ensure a uniform barrier, termiticide labels prescribe the volume, concentration, and locations for the application of the termiticide. This means relatively large volumes of termiticide solution are needed to adequately treat the soil in and around the foundation walls, support piers and soil areas to be covered with concrete (slab areas).

Pretreats normally require more than one visit to the site. Various parts of the structure are treated as they are ready during each visit. Ideally, the builder should notify you before any additions are poured and after final backfill is complete. Before each application, you must notify the builder, construction superintendent, or similar responsible party, of the intended termiticide application and the intended sites of application. You must also instruct the responsible person to notify construction workers and other

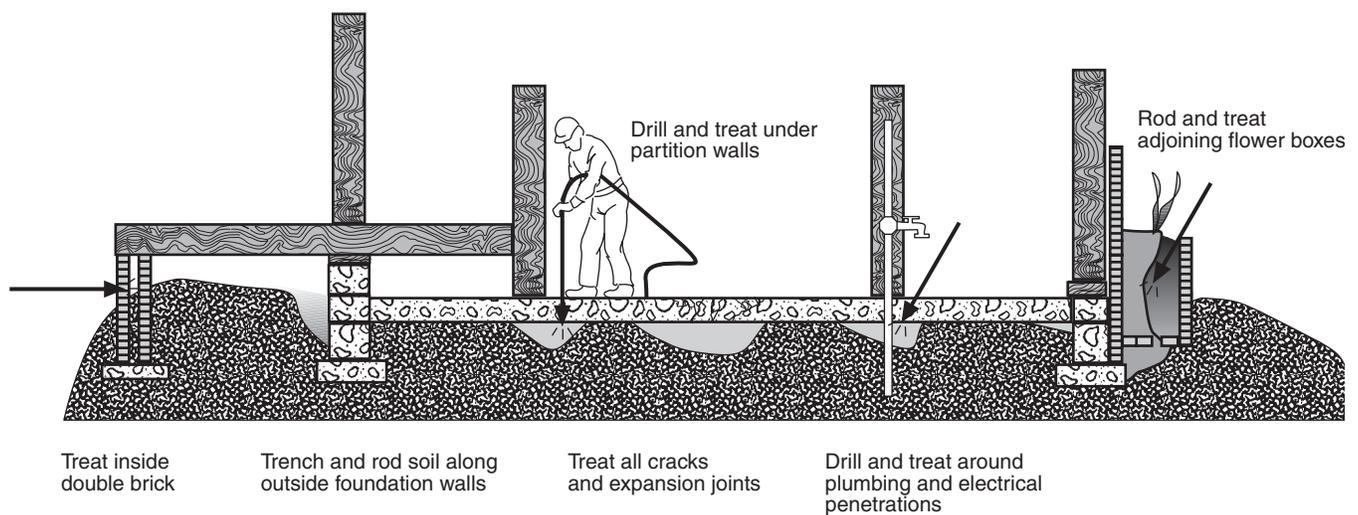


Figure 2-14. Common treatment areas in a structure. Termiticide is applied to soil adjacent to the foundation wall and footings, beneath cracks and expansion joints, around plumbing and electrical penetrations, and in other locations where termites may invade a structure.

individuals to leave the treatment area during application until the termiticide is absorbed into the soil. You should instruct them not to disturb the treated soil until slabs, footings, or other ground coverings are in place. Disturbance of the treated soil can leave a gap in the treatment barrier that could potentially allow termite access to openings in the structure.

There are two basic pretreat schedules, depending on construction type, as follows:

Slabs or basements — These treatments require at least two, and sometimes three, visits to the construction site. The first trip includes treating soil under the main slab and garage before the vapor barrier is placed down and concrete poured. The areas inside the foundation wall (expansion joint area) of the main slab and garage are also treated. Any masonry voids (hollow block walls) are treated as well. The second trip includes treating soil under the main slab and expansion joint areas of attached porches or slabs before additional concrete is poured. If these areas are not treated prior to pouring, the slab area must be drilled and treated later when the outside foundation walls are treated. The third trip includes treating soil adjacent to the outside foundation walls. This is normally done after all sod and landscaping activities are completed.

Crawl spaces — These treatments require three visits to the construction site. The first trip includes treating the soil along the inside of foundation walls and around support piers. Any masonry voids (hollow block walls) are treated. The second trip includes treating the garage slab and any attached porches, patios, etc. before the concrete is poured. The third trip includes treating soil adjacent to the outside foundation wall. This is normally done after all landscaping activities are completed.

It is necessary to know the correct dilution rate and volume of termiticide that should be applied in or around various structural elements during the construction process. It is a violation of state and federal pesticide laws to apply termiticides at concentrations or volumes less than label prescribed rates. Termiticide labels give detailed application instructions that you should read and follow each time you perform a pretreat. Application rates vary from product to product so be sure to review the label to know the correct rate. In situations where soil will not absorb the volume of dilution required, most labels allow decreasing the volume with a corresponding increase in concentration. This is usually accomplished by doubling the rate and applying half the normal volume of water.

The volume of termiticide applied to various structural elements during different phases of

construction is the same for all termiticides. These volumes are as follows:

1. Soil to be covered by a slab is treated at the rate of 1 gallon per 10 square feet. If the fill is coarse gravel, the application rate is 1.5 gallons per 10 square feet.

2. Soil in critical areas such as along foundation walls of crawl space construction, under expansion joints of slabs, around plumbing, inside bath traps, and around utility entrances or other features that penetrate slabs are treated at a rate of 4 gallons per 10 linear feet per foot of depth. This includes fill areas inside chimney foundations and earth-filled porches. Trenching and rodding along perimeter walls is also done at the rate of 4 gallons per 10 linear feet. Rodding should be spaced in a manner that will allow for a continuous chemical treated zone to be deposited but should not extend below the footings. Use low pressure. When the top of the footing is exposed, treat the soil adjacent to the footing to a depth that does not exceed the bottom of the footing.

When treating foundation walls deeper than four feet you should apply termiticide as the backfill is being replaced. If this cannot be done, you can treat the soil to a minimum depth of four feet after the backfill has been installed. Rodding in a trench followed by flooding of the trench and treating soil placed back in the trench is the best way to create a vertical continuous termiticide treated zone when compared to rodding alone.

3. Void spaces or hollow masonry construction (walls, piers, etc.) are treated at a rate of 2 gallons per 10 linear feet. Where multiple voids exist — such as a concrete block wall — each running void is treated at the 2 gallons per 10 linear feet rate. The row is considered as a single void regardless of the number of “cells” or chambers in each block (a 10-foot-long wall would require 2 gallons).

It is important to remember that treatments cannot be made under conditions where soil is water-saturated. Termiticide labels do not allow this because the danger of contaminating ground or surface water is high in these situations. Special precautions are necessary for pretreating structures that contain wells or cisterns within the foundation. In these cases, you cannot treat the soil while it is beneath or within the foundation or along the exterior perimeter using standard procedures. Instead, you must use the treated backfill method where soil is removed and treated in a location away from the foundation and then put back in place.

Post-construction treatments

Post-construction treatments are generally applied as an exterior trench and rod treatment at a

rate of 4 gallons of termiticide per 10 linear feet per foot of depth down to the top of the footer or a maximum of 4 feet. When drilling and rodding concrete slabs or basements indoors and concrete patios, walkways and driveways outdoors, termiticide is also applied at the rate of 4 gallons per 10 linear feet, with drill holes approximately 12 inches apart. Two gallons per 10 linear feet is the standard label rate for treatment of masonry voids, hollow blocks and other special situations.

When a well or cistern is in close proximity to the structure, rodding into the trench is not usually done.

Instead, soil is removed from the trench, placed on plastic sheeting, treated with termiticide, and then placed back into the trench. Many companies don't offer treatments for plenum construction in which the crawl space doubles as a return air space for the heating and air conditioning system.

The steps used to apply a thorough soil treatment around the foundation depend generally on the type of construction and specifically on the conditions associated with each individual infestation. General treatment instructions for the most common construction types are listed below (See also Figure 2-15).

Post-construction termiticide treatments for common types of construction

Slabs or basements

Outside

1. **Trench and rod into trench:** One method to prevent termites from building tunnels up the sides of foundation walls and entering the structure is to inject a chemical barrier into a trench dug adjacent to the wall, up to a width and depth of 6 inches, treating the backfill as it is replaced. Insert the rod into the bottom of the trench down to the top of the footer, but no deeper than 4 feet into the soil. Insert and remove the rod at regular intervals to ensure a uniform distribution of termiticide down along the foundation wall using 4 gallons of termiticide per 10 feet per foot of depth.
2. **Drill/treat under slabs:** For slabs attached to a structure such as porches, patios or carports, holes are drilled into the slab, no more than 12 inches apart for treatment. The treatment rod is inserted into each hole and 0.4 gallon of termiticide per foot of depth is discharged beneath the slab. After treating under the slab, the holes are plugged with cork or rubber plugs, cemented and smoothed over.
3. **Scrape off tunnels:** Scraping mud tubes off of the foundation and basement walls allows monitoring for reinfestation. The only situation that does not necessitate tunnel removal is when aboveground bait stations are installed over active mud tubes specifically to allow termites to enter and feed on the contents.

Inside

1. **Treat expansion joints:** Expansion joints of the foundation wall can be treated from the inside of the home by drilling along the foundation wall at approximately 12-inch intervals.

Any floor coverings should be moved back at least 3 feet from the walls. Having customers sign a release form holds the company blameless if the covering isn't replaced exactly as it was before treatment. Some companies hire a specialist to handle the removal and replacement of floor coverings. Linoleum or vinyl tile that must be cut can be heated for greater pliability. The application rate along expansion joints is 4 gallons per 10 linear feet. Holes should be plugged with cork and capped with cement following treatment.

2. **Treat bath traps and slab penetrations:** Utility pipes embedded in slabs, including water, sewer and sometimes electrical conduits, provide adequate points of entry for termites. When cement hardens and shrinks, a thin crack is left between the pipes and slab. Sometimes a square opening called a bath trap is left agape when the slab is poured where the pipes will be installed. This area needs to be treated. With permission from the homeowner, a bath trap vent is installed (if none exists) for treatment and periodic inspection. A bath trap vent is installed on the backside of the wall containing the plumbing. Center the opening on the pipes inside the wall. Measure how far the tub drain is from the sidewall to get an accurate idea of where the pipes are. Cut an approximately 9½- by 8½-inch opening with a keyhole saw. Place something below on the carpet to facilitate cleanup. The opening should be just a bit smaller than the vent and located right above the baseboard. If any termite activity or damage is evident at this time, add them to your inspection graphs. After treatment, attach the vent cover. Prepare the 1-foot by 1-foot bath trap slab opening for treatment by removing all form boards and grade stakes that may have been

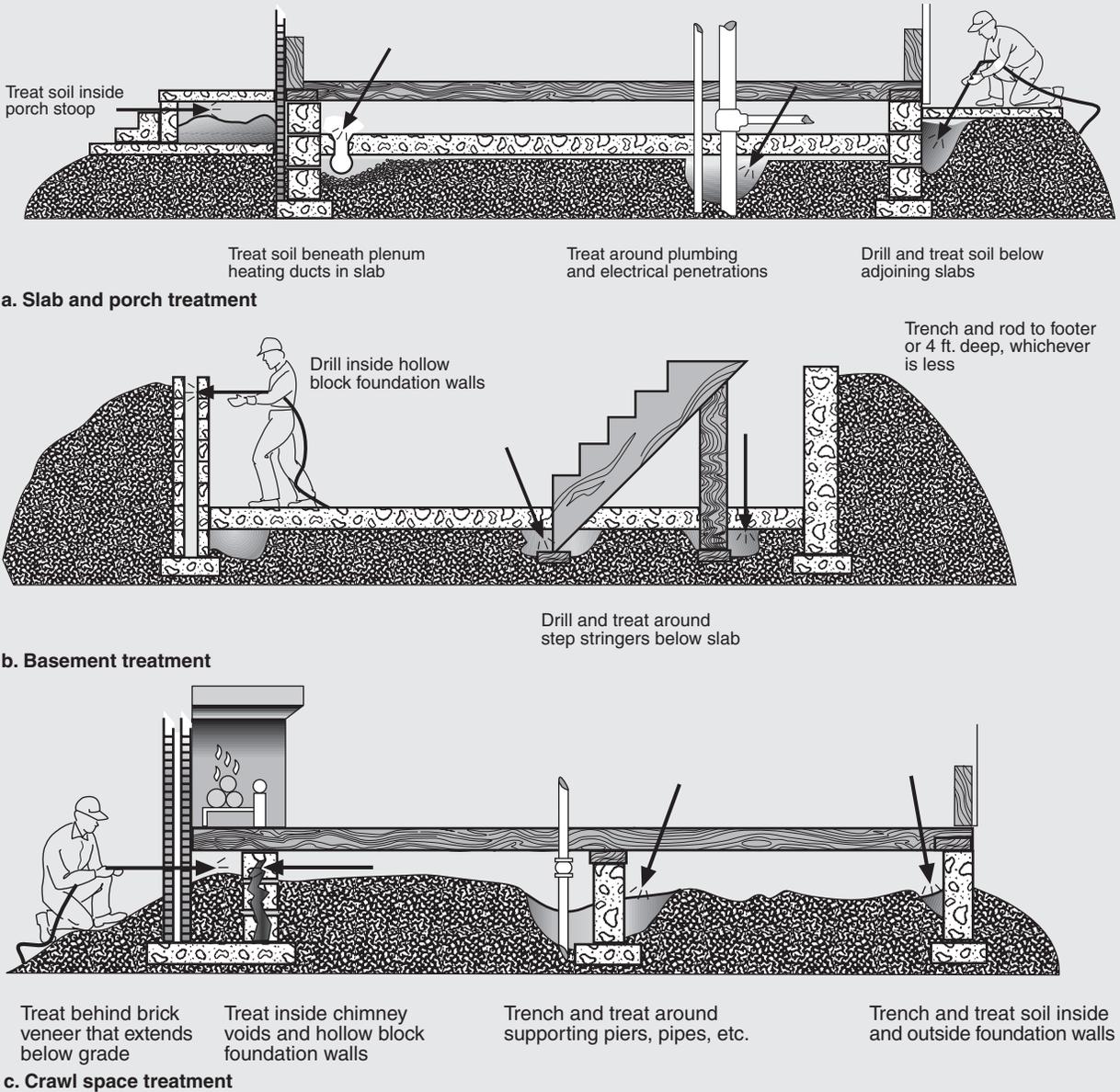


Figure 2-15. Some of the areas that must be treated during a post-construction treatment to (a) slabs, (b) basements and (c) crawl spaces. It is important to identify and apply termiticide to potential subterranean termite entry points that are unique to each construction type.

left there. Then, remove enough soil so that a 2-inch-deep area can be evenly treated with about one pint of termiticide. After applying the termiticide, cover treated soil with $\frac{1}{2}$ inch of untreated soil. If the entire area under the bathtub is dirt, treat according to pretreatment calculations, based on 1 gallon per 10 square feet and apply it evenly throughout. If the slab was poured without a bath trap opening, and cement encases the pipes instead, needle treat the crack around each pipe and any expansion materials between the pipe and slab at the rate of $\frac{1}{2}$ gallon of termiticide per pipe.

- 3. Plumbing penetrations:** Areas around pipes and plumbing not in the bath trap area are

treated by vertical drilling. Use of a drill gauge is recommended to avoid drilling too deep and puncturing utility lines. Use of a ground fault interrupter is also essential for interrupting the electricity going to the drill whenever the bit touches a grounded metal object. The ground fault interrupter also protects the operator from a fatal line-to-ground shock in the event of an electrical short. Use the standard rate of 4 gallons per 10 linear feet. Patch the holes with rubber or cork plugs and cap with cement. All areas with plumbing penetrations through the slab need to be treated appropriately. This includes kitchen, utility room and water heater. Some pipe systems may be interconnected.

4. **Settlement cracks:** Termite damage on an interior wall usually indicates there is an expansion joint, a wall that extends below the slab, or a crack in the slab under the partition wall. Without removing baseboards or shoe molding, treat these areas by vertically drilling as close to the wall as possible, along the joint or crack, spacing the holes about 12 inches apart. Use some type of vacuuming device to remove the drill dust and avoid spreading it throughout the structure. Apply termiticide at the rate of 4 gallons of liquid per 10 linear feet.

Special considerations

1. **Air ducts:** Homes that have air ducts embedded in the slab with vents into the structure (as in perimeter heating) must be examined and treated carefully to avoid drilling into the ducts and contaminating the home.
2. **Horizontal short/long soil rod:** The horizontal rod treatment is used to avoid drilling into floor coverings such as expensive tile, stone or parquet flooring by drilling through the slab foundation wall from the outside of the structure below the level of the soil. This has to be done before exterior trench and rod treatments. To establish an effective chemical barrier that protects perimeter expansion joints, horizontal drilling must ensure that the treatment rod applies termiticide as close to the bottom of the slab underside as possible when inserted. To be certain that drill holes are indeed beneath the slab, measure from the windowsill to the floor on the inside of the structure. Measure this same distance down on the outside of the window, and then add about 6 inches for the thickness of the concrete slab. After drilling the first hole, check inside to make sure the hole was drilled properly. Insert the treatment rod to apply the termiticide at the 4-gallon-per-10-linear-foot rate, then patch the horizontal drill holes with mortar mix. The long rod soil treatment is used only when it is not possible to drill on the inside around slab penetrations or settlement cracks. Because of the distance covered with the long rod, the likelihood of deflection away from the slab by a rock, pipe or other object is increased. Measure down from the windowsill to the floor as for the short rod treatment to find the bottom of the slab and drill every 12 inches. Apply termiticide with the long rod at the 4-gallon-per-10-linear-foot rate, and patch with mortar mix.
3. **Hollow block foundations:** The hollow concrete blocks used for supported or floating

slab foundation walls, contain either two or three voids. Drill horizontally into a test block to determine which type of hollow block was used. After determining the number of internal voids, drill every void and mortar joint in a line of blocks as low as possible to the footer. If necessary, use a depth gauge to avoid drilling utility lines. Apply termiticide at the 2 gallons of liquid per 10 linear feet rate, and patch drill holes with mortar mix.

4. **Chimney:** Though voids in chimneys are difficult to predict, they are in need of chemical barriers. Space drill holes along the bottom edge of the fire box about 12 inches apart. Treat at 4 gallons per 10 linear feet, and patch the holes with cement.

Crawl spaces

Outside

1. **Trench and rod into trench:** To prevent termites from building tunnels up the sides of the foundation and entering the structure, a chemical barrier is applied in a trench around the outside of the foundation wall. Apply at the rate of 4 gallons liquid termiticide per 10 linear feet per foot of depth to the footer. Rod into the soil beneath the trench. You should penetrate the soil all the way down to the top of the footing, or to a maximum of 4 feet. Insert and remove the rod frequently to achieve a uniform distribution of termiticide.
2. **Drill/treat adjoining slabs:** Drill holes for treatment of porches, patios, carports or slabs attached to a structure are spaced no more than 12 inches apart. Treat with 4 gallons of liquid per 10 linear feet then plug the holes, fill with cement and smooth it to match the texture of the surrounding cement surfaces.
3. **Scrape tunnels:** All tunnels must be removed from crawl space and foundation walls. This allows you to assess whether reinfestation has occurred during subsequent annual inspections and removes any living termites inside the tubes.

Inside

1. **Trench:** A chemical barrier is needed around the inside of the foundation walls, around piers, utility pipes and drains, extending into the soil. The trench is to be dug no deeper than 6 inches, treated at the rate of 4 gallons per 10 linear feet per foot of depth to the footer and backfilled with treated soil.

2. **Scrape tunnels:** All tunnels must be removed from crawl space and foundation walls. This allows you to assess whether reinfestation has occurred during subsequent annual inspections and removes any living termites inside the tubes.

Special considerations

1. **Hollow block:** Crawl space foundation walls and piers are often constructed of concrete blocks with either two or three holes. Once the number of holes is confirmed by examining the top of walls and piers, or by test drilling, you need to drill each void and mortar joint in a course of blocks. Beware of hidden joints in the corners. Drill from inside the crawl space to avoid drill holes on the exterior. Holes should be drilled in the row of block closest to the ground at the rate of 2 gallons liquid termiticide per 10 linear feet.
2. **Chimney:** The various types of chimney construction offer easy access to termites. A chimney base within the crawl space is often constructed much like a foundation wall or pier with a footing. Holes are to be drilled and treated into the center void of the chimney, into the brick or block foundation, then the soil around the base trenched and treated.
3. **Porches and stoops:** Slab porches or stoops poured next to the foundation wall are a common entryway for termites into a home built over a crawl space. Construction crews often discard wood scraps in the dirt-filled porch area before the fill is added. Dirt-filled porches can be treated with a long rod from both sides to ensure adequate coverage inside the porch area. Drill holes near the foundation wall, just under, and as close to the slab as possible. Insert the treating rod into each hole more than half the distance across the porch, pull back and apply the liquid termiticide at the 4 gallons per 10 linear feet rate. Fill the drill holes with mortar mix. Since the long treating rod can be diverted, over long distances, this method is used only when vertical drilling from the top is not possible and on porches that are no longer than 8 to 10 feet. Short rodding is used in dirt-filled porches when it is not possible to drill from the top or from the sides. Drilling is done from the crawl space into the porch. Holes are drilled about 12 inches apart and termiticide applied at the 4 gallons liquid per 10 linear feet rate.
4. **Sanitation:** Since termites feed on cellulose, all such debris must be thoroughly raked and

removed from the crawl space before treatment begins. All wood-to-ground contact must also be identified and eliminated. Remove all form boards from foundation walls, piers, or chimney foundations. The homeowner should be advised to have any wooden structural supports replaced with steel or concrete by a suitable contractor.

5. **Ventilation/plenum construction:** Building codes and minimum housing standards normally require good ventilation of crawl space areas, as well as an 18-inch clearance between the soil and untreated subflooring. HUD Minimum Property Standards require at least four foundation wall ventilators, one at each corner of the space. Vents on one or two adjacent sides of the foundation do not provide adequate ventilation, and additional vents should be installed. Vents should be open year-round, closed only during the coldest weather. During treatment, a fan must be placed across the access door to draw air in through the vents and out the access door. When treating plenum heating construction, the air circulation system of the structure must be turned off until the application has been completed and all termiticide has been absorbed by the soil.

Walls

Brick veneer

- Brick veneer that is placed over concrete blocks and extends below grade is treated the same in both basement/slab and crawl space constructions. Drill one hole in the wall mortar joints between every other brick in one course of bricks, at about soil level, but not above sill level. Treating at or above the sill plate presents the possibility of contaminating the interior of the structure. With slab construction in particular, drill at least one course of brick below the weep holes, treat at 2 gallons of liquid termiticide per 10 linear feet, and patch drill holes with mortar mix.

Wall voids

- When foaming wall voids such as those around doors, windows and decorative trim, determine the spacing between wall studs (16 inches) and drill immediately above the baseboard. Use a $\frac{3}{16}$ inch drill bit for windows and doors and $\frac{7}{64}$ inch for trim. Treat with foam to the point of run off. Conventional termiticide can also be used. Patch holes with an appropriate filler.

Other treatment strategies

The banning of soil termiticides containing chlorinated hydrocarbons in 1988 led to replacement chemicals with a different mode of action and shorter residual life in the soil. The reduction in efficacy of soil termiticides during that era, along with an increasing desire for integrated pest management (IPM) strategies that minimize the amount of pesticide used, led to the development of newer strategies for managing subterranean termite infestations. The three most common strategies that are being used are wood treatments, physical barriers and feeding toxicants called baits.

Borates. Borates are inorganic minerals that provide long-term, preventive protection against virtually all wood-destroying organisms when applied directly to wood. They are able to penetrate deep into the wood fibers of even the largest pieces of wood. Furthermore, unlike conventional organic termiticides, borates work well in wood with high moisture content.

Borates are easy to use, especially in areas that are difficult to access and do not lend themselves to conventional approaches. These areas include crawl spaces, attics, wall voids, unfinished basements, decks, boat houses and log homes. Recently, borates have been mandated for use in some states for preconstruction treatment of aboveground wood and framing. In these cases, it has been shown to be effective for protecting structural wood when the bottom 4 feet of unfinished wall framing and the sill plate are treated.

When used according to label instructions, borates are nontoxic to humans and other vertebrates. It is wise to use standard safety precautions such as wearing gloves, boots and a face shield during application. Note, however, that because of its toxicity to plants, you need to cover plants completely with plastic sheeting during application. It is also important to protect the soil and roots around these plants from contamination. The following treatment specifications should be followed.

- **Crawl space or unfinished basement:** Apply a borate solution at low pressure with a fan spray at the rate of 5 gallons per 1,000 square feet until the point of runoff to the box sill, the chimney header and the beams above crawl space piers or above basement supports.
- **Finished basement:** Treatment is more difficult in finished than in unfinished basements because ceiling tiles limit access. Treat accessible box sill areas and interior wall voids around plumbing and infested areas at the same rate as crawl spaces and unfinished basements. Drill $\frac{3}{16}$ -inch holes above the baseboard of interior wall voids approximately every 16 inches

between each wall stud. Apply 1.5 to 2.0 ounces of borate solution to each hole or to the point of runoff. Plug holes with wood filler.

- **Slabs:** Drill $\frac{3}{16}$ -inch holes above the baseboard of interior wall voids around plumbing areas, expansion joints, settlement cracks and infested areas between wall studs approximately every 16 inches. Apply 1.5 to 2.0 ounces of borate solution to each hole or to the point of runoff. Plug holes with wood filler.
- **Infested wood:** In accessible areas, drill holes every 6 inches. When wood is large enough, drill holes in a star pattern. Treat the drill holes by injection, applying borate solution under pressure to the point of runoff.
- **Pre-construction:** Before or during construction, apply borate solution to the point of runoff, using a fan spray at low pressure, to all exposed timber at the rate of 5 gallons per 1,000 square feet.

Baits. Baiting is generally less invasive to homeowners than a barrier treatment. The goal of baiting is to eliminate termites in a structure by intercepting active termite colonies around the home and feeding them a toxic food source. This is accomplished by placing stations in the ground around an infested structure or over active mud tubes on or inside the structure. Outside stations initially contain wood or some other food material that does not decompose quickly and serves as a monitor. The monitor is not toxic to termites. Instead, the monitor sustains termite feeding activity until the station is later checked by a pesticide technician (Figure 2-16).

Once termites have found the monitor and the technician determines they are feeding inside the station, the monitor is replaced with toxic bait. Baits contain a slow-acting chemical toxicant. The colony feeds on the bait, passes it around the colony through food-sharing, and later succumbs to the effects of the bait. Good baits must be slow-acting so that there is sufficient opportunity for the toxicant to be transferred. If the toxicant is too potent or works too quickly, donor termites behave differently or die without passing the toxicant to a large number of nest mates. The time needed to eliminate termite colonies with bait is unpredictable and may take several months, depending on the time needed for termites to locate the stations, consume the bait and transfer the toxicant throughout the colony.

You should follow the bait manufacturer's step-by-step procedures in response to termite feeding activity. The following steps define a typical baiting cycle for subterranean termites:

1. Stations with monitoring devices are placed into the soil.

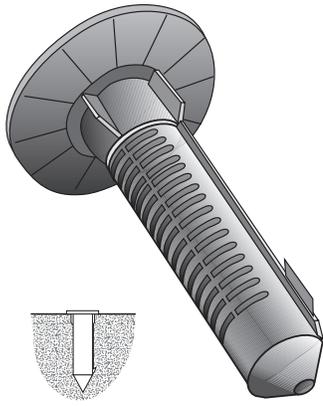


Figure 2-16. Generalized design of bait stations used to deliver bait toxicants to subterranean termite colonies. A typical baiting cycle includes installing stations in the soil, checking them regularly to determine when termites are in the station, placing bait into stations with live termites, and continued monitoring to evaluate activity.

2. Termites discover and occupy monitoring devices in the station.
3. Active monitoring devices are removed and bait is placed inside active monitoring stations.
4. Termites from monitoring device are placed on bait inside station.

It is normally recommended that you check each station at monthly intervals. Regular follow-up is a critical part of baiting so that you can evaluate when each step needs to be initiated for each monitoring station. Regular monitoring ensures that the system works effectively in the shortest possible a time. Typically, you continue to monitor all stations for at least one year after the initial baiting cycle to detect whether any new colonies locate the monitors and another baiting cycle needs to be initiated.

Bait toxicants vary in their toxicity to termites. Most bait toxicants are synthetic insect growth regulators (IGRs) because these chemicals make the best active ingredients. IGRs interfere with termite development by causing the death of termite workers and nymphs during the molting process. Since they don't influence any other behaviors, they do not interfere with behaviors that are important for transferring the toxicant. In effect, they are nontoxic to termites until they begin the molting process, but then they are fatal. A few bait toxicants are slow-acting nerve or stomach poisons. These slow-acting poisons interfere with normal functioning of body systems. Since they interfere with regular body functions, they can also interfere with the normal behaviors that are important for transferring bait toxicant.

Physical barriers. Two types of physical barriers have potential to be used for prevention of subterranean termite entry into structures. They are not currently being used in conventional construction or post-construction termite treatments, so only a

brief explanation will be given here. One barrier uses sand that is uniformly sized at $\frac{1}{16}$ inch in diameter to replace soil under the foundation elements. Although the sand is typically placed there before construction, it may also be done after construction, but the process is expensive. The size of the sand particle is critical. Termites can pick up and remove sand particles that are smaller than $\frac{1}{16}$ inch to make a tunnel, and they can maneuver in between sand particles larger than $\frac{1}{16}$ inch. For an effective termite-proof barrier, sand particles must be uniform — more so than even 16-mesh sand that is available from quarries. Quarry sand actually varies within the 10- to 20-mesh range, so special measures have to be taken to purchase or to prepare sand with a uniform particle size if this method is to be used.

Another barrier, consisting of finely woven stainless steel mesh, can be placed below the foundation before pouring concrete. The mesh construction is too strong for termites to chew through and the holes too small for their bodies to fit through.

Wells, cisterns and drains

Treatments for subterranean termites must not damage or contaminate water sources. The water sources that are typically at highest risk of contamination by a termiticide treatment include wells, cisterns and subsurface foundation drains. Wells are holes dug or drilled to obtain and store drinking water, while a cistern is a nonpressurized underground tank used to store water. Subsurface foundation drains (sometimes called “French” drains) are underground perforated pipes that remove subsurface water. They are usually installed to correct moisture problems under and around foundations.

Although you'll find that it is more challenging to treat homes with wells, cisterns, or foundation drains, there are options for protecting these homes. Most liquid termiticide labels permit the treated backfill method. This is a time-consuming method, but the environmental risks from water contamination certainly justify using it. This method involves removing the soil from the trench along the foundation and placing it onto a waterproof tarp or wheelbarrow, where it is treated with the correct amount of termiticide. This treated soil is then placed back into the trench.

It is critical to read and follow all directions on the termiticide label. Most termiticide labels either prohibit or limit normal liquid soil treatments in these situations to prevent accidental contamination of water. Many give specific instructions based on the distance these water sources are from the foundation. Label language varies from product to product, so don't assume they are all the same.

If you are told by the homeowner that a well or cistern has been abandoned and is not in use, you should ask to see documentation from the state that verifies this claim. Abandoning a well or cistern does not simply mean that the homeowners have stopped using it. The well, cistern and groundwater may still be contaminated by termiticide treatments when not in use. Documentation from the state usually includes statements indicating that a water supply has been permanently disabled and restored in a manner that protects groundwater from contamination. Only when this documentation has been provided will you

be able to legally treat the termites using standard soil treatment methods.

Bait systems are a good alternative to liquid soil treatments in situations with wells, cisterns, or foundation drains. Baits can be installed according to the label in exactly the same way they would be installed around a typical home with little to no risk of contamination to groundwater. If you would like to use a bait system in these situations, there are several products on the market. Talk to distributors or bait manufacturers directly to get information about their products.

DRYWOOD TERMITES

Identification

Drywood termites belong to the family Kalotermitidae. They are common along the Gulf Coast and California, where relative humidity is high, but no species in this family occur naturally in the Midwest. As their name implies, drywood termite colonies are found inside wood with low moisture content. They do not require contact with soil. Colonies that infest small to medium-sized pieces of wood or furniture can be transported to nonnative regions where they re-infest. Infestations in the Midwest are normally due to transporting infested wood or furniture from southern areas. When this happens, the colony can survive indoors if there is high relative humidity, but they will not persist or survive outside under natural conditions.

Small drywood termite colonies are confined within wood and produce small fecal pellets that look like tan dust grains or yeast particles, which are ejected from the tunnels. These pellets have lengthwise ridges that make the pellet hexagonal in cross section and are diagnostic (Figure 2-17). Drywood termites easily can be distinguished from subterranean termites by the presence of these pellets because subterranean termites don't produce pellets. Drywood termite swarmers are also slightly larger than subterranean termites and lighter in color. Drywood swarmers are $\frac{1}{2}$ to $\frac{5}{8}$ inch (9–15 mm) in length, whereas subterranean swarmers vary from $\frac{1}{3}$ to $\frac{1}{2}$ inch (8–12 mm). Daytime swarms are most common for drywood termites, but records of night swarming in a few extremely hot, dry areas have been observed.

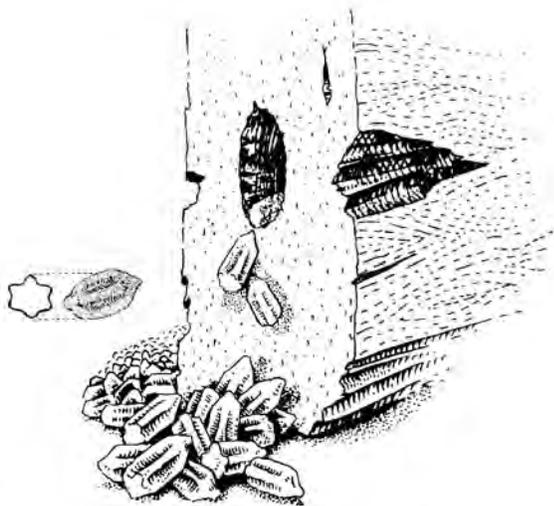
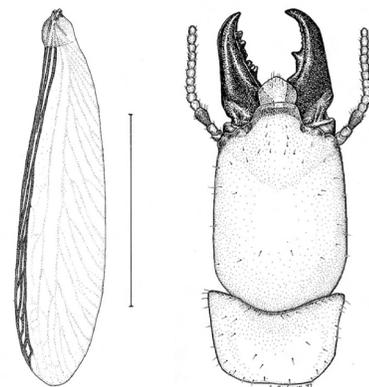


Figure 2-17. Drywood termite fecal pellets. Drywood termite damage can easily be distinguished from subterranean termites by the presence of pellets in the tunnels that look like tan dust grains or yeast particles.



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Figure 2-18 (left). Drywood termite swarmer wing. Drywood termite wings are recognized by the three parallel, dark, thickened veins that run along the front edge of the wing.

Figure 2-19 (right) Drywood termite soldier head. Soldiers of some species are recognized by their enlarged, rectangular, reddish brown heads with long, swordlike mandibles that have teeth along the edges. These heads are adapted both for plugging tunnels and for snapping at intruders.

Drywood swarmers have three or more dark, thickened wing veins along the front edge of the wings and cross veins running between these longitudinal veins (Figure 2-18). The front wing scales are large and overlap the hind wing scales. Soldiers have antennae that are shorter than the width of the head and the third antennal segment is larger and darker than the other segments. The soldier mandibles have teeth. There are three or more teeth on the left mandible and one or more on the right (Figure 2-19). Some soldiers have shortened, blunt heads with tiny, recurved mandibles that are held under the front of the head capsule (Figure 2-20).

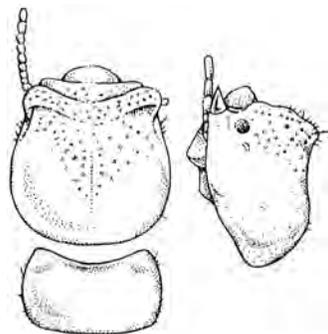


Figure 2-20. Drywood termite soldier head. Soldiers of some species are recognized by their shortened, blunt heads with tiny mandibles that are barely visible. Their heads are adapted only for plugging tunnels in the wood against intruders.

In relation to other groups, drywood colonies are typically small, ranging from a few thousand to ten thousand individuals at most. A single piece of wood can be infested by numerous colonies. Infestations are found in furniture, isolated boards and structural timbers of buildings.

Biology and behavior

Reproductives

Future kings and queens develop full wings and darkened bodies before leaving the parent colony to mate and begin new colonies elsewhere. This process is called swarming and these future kings and queens are often called swarmers. The purpose of swarming is to disperse away from the parent nest. No mating occurs during swarming. Once swarmers have moved away from the parent nest, they land and drop their wings. After dropping their wings, swarmers are called dealates. Dealates locate one another using chemical and tactile signals and then begin searching for suitable mating and nesting sites.

After swarming, loss of wings, and pairing, new kings and queens select a piece of wood and work together to chew a small vertical hole into the wood — wide enough for only one of them to enter at a time. They take turns entering and excavating wood from this hole until it is about $\frac{3}{8}$ inch deep. Then they seal themselves inside by making a plug of wood mixed with body secretions. The pair enlarges the small hole into a royal cell by excavating a horizontal pear-shaped area within a ring of spring wood. This creates a broad, flattened area about $\frac{3}{8}$ inch under the

surface. This is where the king and queen mate. After mating, they enter a period of inactivity that can last for up to nine months. Following this inactive period, the queen lays her first eggs.

Soldiers

Relatively few soldiers are found in a colony. They are responsible for colony defense. Their enlarged heads and long mandibles are adaptations to plug holes in the tunnels or inflict a painful bite on invading enemies (Figure 2-21). Soldiers rely on the worker caste to feed them.

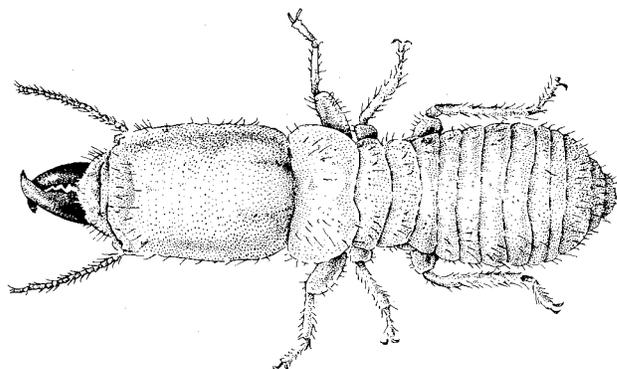


Figure 2-21. Drywood termite soldier.

Eggs and nymphs

Two to five eggs hatch into young nymphs that begin to enlarge the nest. They excavate a single tunnel with occasional lateral passages at 90-degree angles. As the nymphs excavate, the queen moves into the advanced portions of the tunnels and lays additional eggs. These eggs hatch and are reared by older nymphs who continue to extend the main tunnel and side passages. The queen and king remain in the advanced portions of the tunnels and eggs are deposited amongst the fecal pellets there. Two years following the entry of the king and queen into the wood, a young colony has normally excavated about 3 cm³ of wood and consists of a primary queen and king, one soldier, and 12 to 20 nymphs.

The queen lays eggs intermittently from late spring until late fall. She lays 1 to 12 eggs every 24 hours during a 7- to 10-day period, then ceases egg laying for 4 to 6 weeks before depositing eggs again. Over a period of 5 to 8 years, a colony becomes mature. When the colony is mature, winged swarmers are again produced from nymphs during summer and fall. The winged swarmers emerge from infested wood and disperse to new locations to nest. Supplemental reproductives can develop from mature nymphs within the gallery system when the primary queen and king die or are absent for some reason.

Feeding and infestation

Drywood termites living inside wood are difficult to detect. They are seldom seen unless they swarm or repair work is done to areas where they have infested. Occasionally, fecal pellets will give some indication of an infestation.

Structural infestations by drywood termites occur most frequently near the roof. One reason for this is that the roof is high enough to intercept their swarming flight path. After landing, dealated queens and kings survey the surface of the roof then enter along the edges of the roof between shingles and sheathing, along the ridgepole, or between rafters and sheathing. Once inside, they usually go into the cracks and crevices between pieces of wood. Common entry points include the junctions of rafter ends and ridgepole, rafter ends and plate, and plate and studding ends. In fewer cases they penetrate directly into the surface of these wood pieces.

The best evidence of a drywood termite infestation is the presence of distinct fecal pellets within galleries that are smooth and contain no soil. Discarded wings are also a good indicator of infestation. Galleries in damaged wood are smooth and composed of chambers connected by tunnels that cut across the grain. The galleries do not follow spring or summer growth rings. Galleries in wood may extend into adjacent boards in trim, flooring, books and furniture.

Fecal pellets are less than 1/25 inch (1 mm) in length, hard and elongate with rounded ends and six flattened sides (see Figure 2-17). The flat sides are formed during water extraction by rectal glands inside the anus. Pellets are normally a light brown-beige color, but they can vary slightly according to the wood that is being consumed. Pellets are normally found inside the galleries, but in some species, they are removed from galleries through round “kick holes.” Kick holes are temporary openings that are closed up with special secretions immediately after the pellets are expelled. The pellets may accumulate in small piles below the kick hole.

The presence of large numbers of swarmer inside a structure is a sure sign the structure is infested. To locate drywood termite colonies, probe wood with a sharp object. In the Midwest, pay close attention to furniture or other wooden objects that were brought from southern areas. In areas where drywood termites are native, check rafters, header joists, ends of ceiling and floor joists, plates, wall studs and flooring. Drywood termites usually consume the inside of wood while leaving a paper-thin layer at the surface. This thin layer offers little resistance to a probe and breaks open with the slightest pressure. Drilling into infested wood and treating individual colonies is sufficient when infestations are localized, but whole-

structure fumigation may be necessary if the infestation is extensive.

Prevention and control

Drywood termite control methods are generally classified as either whole-structure or localized treatments. Whole-structure treatments are used to eliminate all infestations in the entire structure at the same time, while localized treatments are used to eliminate infestations in a piece of furniture, a single board or a small area. In the Midwest, where drywood termites do not naturally occur, nearly all infestations are controlled by localized treatments. When using localized treatments, you must ensure that there are no small infestations left undiscovered that could persist if you treat only a small area or single item.

Localized treatments for drywood termites are generally accomplished by drilling into the galleries of infested wood and injecting a killing agent such as chemical liquids, dusts or foams. In addition, nonchemical methods such as freezing, heating, electrocution or microwaves have been examined and tested. The manner in which nonchemical methods are accomplished is unique to each method. Varying levels of efficacy are reported from chemical and nonchemical methods.

Chemical treatments range from 13 percent to 100 percent effective in controlling drywood termite infestations. Their effectiveness is depends on the type of chemical used. Synthetic organic insecticides are the most effective. Borates have been tested but did not effectively control drywood termites in one study. There are no studies that have verified the efficacy of botanicals like orange oil or neem. Liquid nitrogen is applied like other chemical treatments, but the mode of action is to cause a sudden drop in temperature that kills the termites. Special precautions should be taken to protect the applicator from injury when using liquid nitrogen.

Some nonchemical options for drywood termite control can be as effective as chemical treatments when applied properly. Heat is one treatment option that has been reported to be up to 100 percent effective. Heat kills termites by disrupting cellular activities and enzymes that are needed for survival. To be effective, infested wood must be heated to a minimum of 120 degrees F and maintained at this temperature for at least 35 minutes. Be careful when treating items that contain heat-sensitive materials such as plastics or wiring. Microwave machines have been developed to treat wood without drilling. Microwaves kill termites by causing fluids inside their cells to boil. Because microwaves are effective in a limited area, you need to make sure that all areas of the tunnel system are equally treated with microwaves. Heat and microwave treatments are both beneficial because they leave

no chemical residues. However, both treatments can damage or discolor the surface the interior of wood. Make sure you don't damage or discolor specialty items such as furniture when using these treatments.

There are good preventive methods to use against drywood termites, including borates or pressure-

treated wood. However, there is usually no need to take preventive measures against drywood termites in the Midwest. The risk of infestation to the structure or to wooden items in the home is so low that the cost of prevention is not worth the potential rewards.

Study questions

Chapter 2 - Termites

1. All termites use cellulose as a food source although they cannot digest cellulose themselves.
 - A. True
 - B. False
2. Subterranean termites are responsible for most of the termite damage in the United States.
 - A. True
 - B. False
3. Which of the following castes are the initial founders of a new colony?
 - A. Nymphs
 - B. Workers
 - C. Primary reproductives
 - D. Secondary reproductives
4. Subterranean termites swarm both day and night.
 - A. True
 - B. False
5. Even after becoming fully mature, subterranean termite workers molt or shed their exoskeletons periodically throughout their entire lives.
 - A. True
 - B. False
6. Which of the following terms describes food sharing that contains regurgitated fragments of wood and saliva?
 - A. Pheromonal food
 - B. Stomodaeal food
 - C. Proctodeal food
 - D. Trophallactal food
7. Over 90 percent of the termites in a subterranean termite colony belong to which caste?
 - A. Larva
 - B. Nymph
 - C. Soldier
 - D. Worker
 - E. Swarmer
8. Subterranean termites can hear airborne sound.
 - A. True
 - B. False
9. Secondary reproductives are relatively common in mature colonies of subterranean termites.
 - A. True
 - B. False
10. Subterranean termite colonies do not have to maintain contact with the soil when the wood itself in a structure is moist.
 - A. True
 - B. False
11. Subterranean termite damage always has a fecal-soil mixture within the tunnels.
 - A. True
 - B. False
12. Which type of slab foundation would you have if a footing is not found when probing down parallel to the foundation wall on the outside?
 - A. Monolithic
 - B. Supported
 - C. Floating
13. Which of the following slab types *does not* include expansion joints as a possible point of entry for subterranean termites?
 - A. Monolithic
 - B. Supported
 - C. Floating

-
14. Floating slabs are designed so that settlement cracks do not occur in them and so are less susceptible to invasion by subterranean termites.
- A. True
 - B. False
15. When trenching and rodding around the perimeter of a structure, the trench should be approximately how deep?
- A. 8–10 inches
 - B. 6–8 inches
 - C. 4–6 inches
 - D. 2–4 inches
16. Drill holes in slabs or adjoining patios, driveways, or sidewalks should be approximately how many inches apart?
- A. 10
 - B. 12
 - C. 18
 - D. 24
17. The standard treatment rate for soil termiticide applications is 10 gallons per 4 linear feet per foot of depth.
- A. True
 - B. False
18. What is the treatment rate for hollow block wall treatments?
- A. 10 gallons per 4 linear feet
 - B. 10 gallons per 2 linear feet
 - C. 4 gallons per 10 linear feet
 - D. 2 gallons per 10 linear feet
19. Which of the following pieces of equipment prevents a sudden drop in water pressure that could suck pesticide into the water hose and contaminate the water supply?
- A. Sprayer pump
 - B. Flow meter
 - C. Spray container
 - D. Backflow preventer
20. Good baits must be slow acting to work well.
- A. True
 - B. False
21. Which of the following chemicals make the best bait toxicants?
- A. Insect growth hormones (IGRs)
 - B. Borates
 - C. Slow-acting nerve poisons
 - D. Slow-acting stomach poisons
22. Drywood termite damage has soil-fecal mixture in the tunnels.
- A. True
 - B. False
23. Subterranean termite wings have two dark, thickened wing veins and drywood termites have three or more dark, thickened wing veins along the front edge.
- A. True
 - B. False

3

BEETLES

Wood-boring beetles are classified in the insect order Coleoptera, which contains all beetles. Beetles have six legs, one pair of antennae, and undergo complete metamorphosis, which means there are four stages of development in the life cycle. It also means there is a change in body form at each stage of development as individuals move from egg to larva, to pupa to adult. Although there are more than 300,000 known species of beetles in over 100 families, a characteristic common among all is the structure of the front wings. The front wings are hardened and form a sheath over the hind wings and the abdomen. These sheath wings, or elytra, form a protective covering to protect the membranous hind wings and soft abdomen.

Wood-boring beetles that damage wood in structures have been grouped together as powderpost beetles, bark beetles, flatheaded borers and roundheaded borers. They belong to the beetle families Lyctidae, Bostrichidae, Anobiidae, Scolytidae, Cerambycidae and Buprestidae. All of these groups can be found in the Midwest. Most adult wood borers are small, usually less than $\frac{1}{4}$ inch long, but some species can be large and colorful.

Wood-boring beetles normally lay their eggs on the surface of the wood. After hatching, the larvae penetrate the wood to feed. Their feeding produces tunnels in the wood. After beetles complete the larval stage of development, they pupate just under the surface, then change into the adult stage while still inside the wood. The adults later chew exit holes to the surface and leave the wood (Figure 3-1).

It is the larvae that do the most damage by their chewing, which can be virtually undetectable without close scrutiny or by splitting open the wood. Normally the only evidence of infestation is the small exit holes at the surface from which adult beetles have already exited. However, if the wood is split open, what is revealed is a record of larval activity, consisting of a labyrinth of tunnels of varying diameter, running mostly parallel with the grain of wood and packed with "frass," a mixture of wood dust and fecal matter.

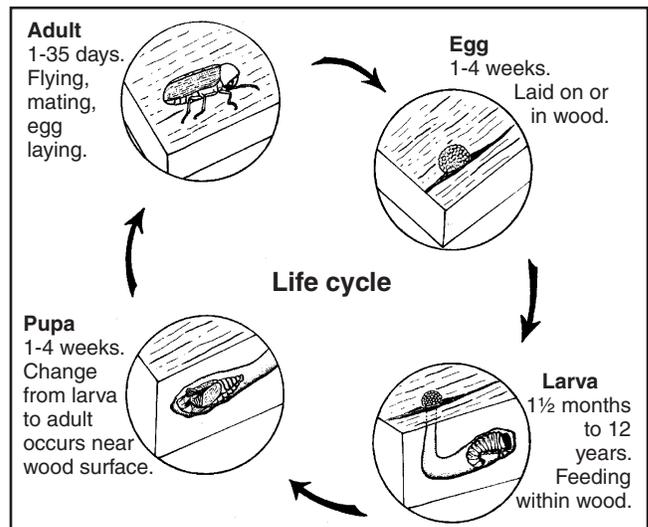


Figure 3-1. Generalized life cycle of wood-boring beetles. Adult beetles normally lay their eggs on the surface of unseasoned wood. After hatching, larvae penetrate the wood to feed, producing tunnels in the wood. After beetles complete the larval stage, they pupate just under the surface and then emerge as adults while still inside the wood. Adults later chew holes to the surface and exit.

Environmental factors can affect the severity of damage from the various species. These factors include geographic location, type of wood, whether hardwood or soft, and the part of the wood infested, sapwood or heartwood. Vulnerable parts of the home include framing, subflooring, hardwood flooring, interior trim, joists, sills and beams, hardwood furniture and tool handles. All parts of a log home are susceptible. Vacation homes are particularly vulnerable to attack because of moisture buildup during long periods without heat or proper ventilation.

Roundheaded borers

Identification

The wood-boring beetle family Cerambycidae is a large one, with over 1,200 species in North America alone. These species are referred to as roundheaded borers because their tunnels in wood are round in

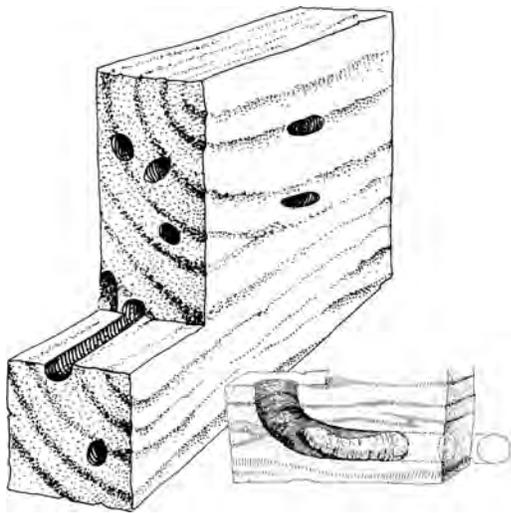


Figure 3-2. Roundheaded borer damage. Roundheaded borers get their name because their tunnels are round in cross section.

cross section. These round tunnels accommodate the enlarged thorax directly behind the beetle larva's head, which is also round in cross section (Figure 3-2).

Adult beetles have distinctive 11-segmented antennae that are often as long as or longer than their bodies. Because of this conspicuous feature, they have acquired the additional name of long-horned beetles (Figure 3-3). Adult beetles vary considerably in shape and size. Among species found in seasoned wood, adults can measure from $\frac{1}{8}$ inch (8 mm) to 2 inches (50 mm) or more. They are elongate and either cylindrical or flattened from top to bottom. They have large gnawing mandibles or jaws. The markings and colors vary from drab species found in softwoods to bold and colorful varieties that infest hardwoods.

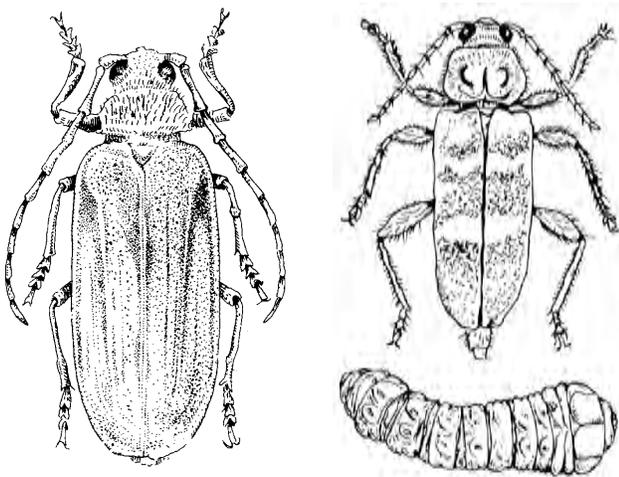


Figure 3-3 (left). Adult roundheaded borer. These beetles are often called long-horned beetles because of their distinctive antennae, which can be as long as or longer than their bodies.

Figure 3-4 (right). Adult and larval stages of the old house borer, one important species of long-horned beetle. Roundheaded borers have an enlarged area directly behind the head, which is round in cross section.

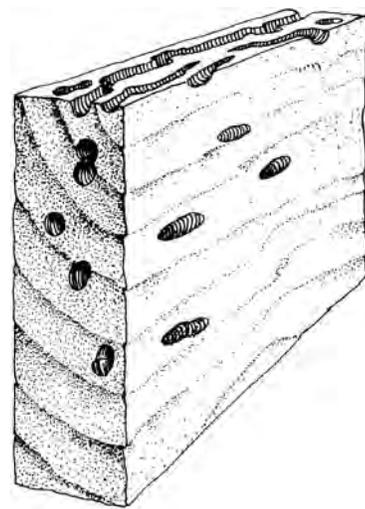


Figure 3-5. Old house borer damage. Notice the round holes in cross section that are typical of all roundheaded borer damage.

One important species is the old house borer (Figure 3-4). The adult can range from $\frac{5}{8}$ to 1 inch (16–25 mm) in length, is slightly flattened and brownish black in color. Gray hairs on its head and forefront are easily rubbed off. A shiny ridge running down the middle of the pronotum and nubs on either side give the appearance of a face. The wing covers may be completely black or have gray patches that form vague bands. The larvae, up to $1\frac{1}{4}$ inch (31 mm) long, can be differentiated from other roundheaded borers by the presence of three eyespots on either side of the head, as opposed to one in other species.

Biology and behavior

Adult females lay eggs singly or in clusters. The eggs are laid in or on bark during warm periods in spring, summer or fall. Larvae hatch in a few days and begin to feed directly under the bark. Some may penetrate into sapwood or further into heartwood. The oval-shaped galleries span up to $\frac{3}{8}$ inch (9 mm) in width and contain a loosely packed fine powdery frass with long, tiny, blunt-ended fecal pellets. The oval exit holes, $\frac{1}{4}$ to $\frac{3}{8}$ inch (6–10 mm) are not easily seen on dark wood (Figure 3-5).

The larval stage lasts from one month to several years, depending on the beetle species and the moisture, temperature and suitability of the wood. At maturity, larvae construct a cell just beneath the surface of the wood and pupate inside this cell. Following pupation, adults chew a hole to the outside of the wood from inside the pupal chamber. This emergence can occur anytime from early spring to fall, depending on the species.

Feeding and infestation

Roundheaded borers that emerge from wood in a structure most likely started their development in

logs or unseasoned lumber before milling, drying, and subsequent construction. They are especially prevalent in lumber sawn from diseased or fire-killed wood that has not been kiln-dried.

Roundheaded borers do not reinfest structural wood because of its dryness. Once they have emerged from structural timbers, there is no risk of further damage by the next generation. However, infestations may not be discovered for some time following construction because the life cycle is prolonged for several months or years when the wood dries after being cut into dimensional lumber.

Flatheaded borers

Identification

More than 150 of the 700-plus species of flat-headed wood-boring beetles in the family Buprestidae are found in the eastern United States. These species are referred to as flatheaded borers because their tunnels in wood are oblong and flattened in cross section (Figure 3-6). Larvae are characterized by well-developed plates on the wide, flat area behind the head (Figure 3-7). It is from the shape of this area behind the head and the shape of the tunnels in cross section that flatheaded borers get their name.

The jewel-like appearance of many species in this family is anything but common, conferring on them the name “metallic” wood borers. Adult flatheaded borers vary greatly in size, ranging from ¼ inch (6 mm) up to 1½ inches (33 mm) in length. Many are beautifully marked with metallic coloring. Their bodies are boat-shaped and fairly flat, with ridged or roughened wing covers (Figure 3-8).

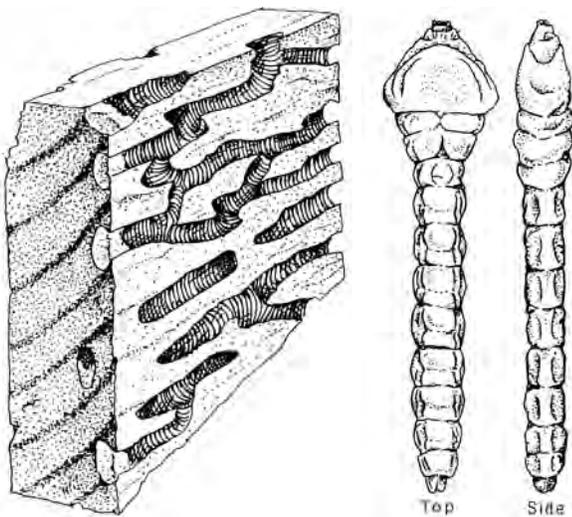


Figure 3-6 (left). Flatheaded borer damage. Flatheaded borers get their name because their tunnels in wood are oval and flattened in cross section.

Figure 3-7 (right). Flatheaded borer larva. These larvae are characterized by well-developed plates on the wide, flat area behind the head.

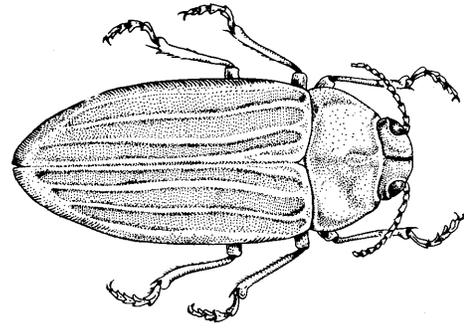


Figure 3-8. Flatheaded borer adult. Their bodies are boat-shaped and fairly flat, with ridged or roughened wing covers. Adults of many species are marked with metallic coloring and are often called “metallic” wood-boring beetles.

Biology and behavior

In early spring or summer, female buprestids deposit eggs within crevices of bark, or at the edges of wounds and wood beneath the bark of dead and injured trees. The larvae that hatch from these eggs are whitish to yellowish and have no legs. When they hatch, the larvae bore under the bark, then into sapwood and heartwood. They carve flat, winding tunnels that are more wide than high and pack them tightly with a mix of light-colored wood and a darker brown, bark-colored frass and pellets. The walls of the tunnels are scarred with fine lines that run crosswise. Dark, dead areas of bark, often with exuding sap, are caused by these burrowing activities.

Mature larvae construct an elongated pupal cell just beneath the surface of the wood. They pupate within this cell and the adults later emerge from the pupa inside this cell. New adults chew an exit hole through to the surface during warm weather. In general, these exit holes are more elongate and oval-shaped than exit holes made by roundheaded borers. Female buprestids mate, lay eggs and die shortly after emerging. Development typically takes one to three years depending on the species, moisture availability, temperature and suitability of the wood.

Feeding and infestation

Flatheaded borer larvae have usually completed development before wood is milled, so the threat of structural infestation is low. They can be highly destructive to freshly cut logs but rarely initiate an infestation in structural wood because of its dryness.

If bark is left on structural timbers that were infested before milling, buprestid larvae continue to develop until the wood becomes too dry to sustain them and may emerge from structural timbers later. When adults emerge from structural wood following construction, it is possible that water may enter through exit holes in siding, trim or roofing materials and could cause additional damage. Thus, repair of emergence holes from flatheaded borers is important both aesthetically and structurally.

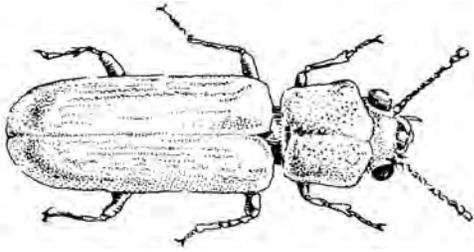


Figure 3-9. True powderpost beetle. Adults are small, somewhat flattened, slender, and shiny reddish brown to black, with rows of small pits on their wings and a relatively large head. Their antennae have a two-segmented club.

True powderpost beetles

Identification

All 90 species of wood borers in the beetle family Lyctidae are referred to as “true” powderpost beetles simply because they were the first to be called such. They are all similar in appearance, varying in length from $\frac{1}{8}$ to $\frac{5}{8}$ inch. They are somewhat flattened, slender, cylindrical and shiny reddish brown to black, with striated wings and a large head. Their antennae have a two-segmented club (Figure 3-9).

Biology and behavior

Adult lyctid females lay 20–50 eggs in the surface pores or cracks and crevices of susceptible wood. They may bore through surface layers to get to sapwood for egg laying. They chew a small amount of the wood to test for starch and moisture content before laying eggs and will only do so when starch content is greater than 3 percent. Lyctids rely on the starches, sugars

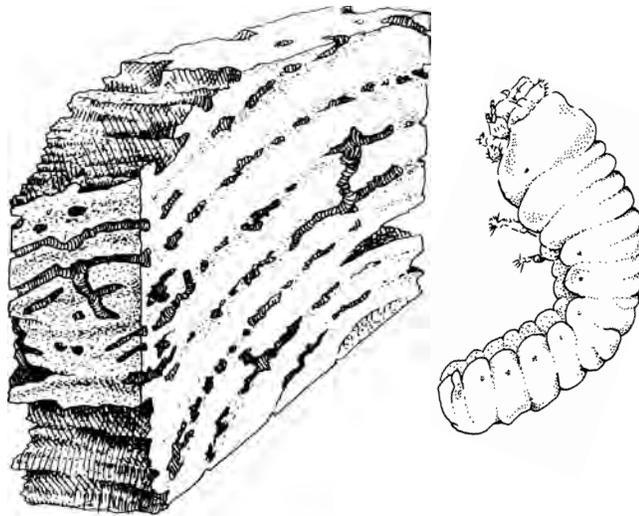


Figure 3-10 (left). True powderpost beetle damage. Tunnels are small, wind throughout the interior of the wood, and intersect with other tunnels. Frass in the tunnels is the finest consistency of any powderpost beetles.

Figure 3-11 (right). True powderpost beetle larva. They are less than $\frac{1}{4}$ inch long, C-shaped, and yellowish white in color, with six legs and an enlarged area behind the head.

and proteins in the sapwood for nutrients since they cannot digest cellulose.

Eggs hatch and the larvae begin to enlarge the pores of the wood into tunnels by chewing along with the wood grain. Later, tunnels veer off course and wind throughout the interior of the wood, intersecting with other tunnels (Figure 3-10). If the larvae encounter the interface of two adjacent pieces of wood while tunneling, they can chew their way from one piece of wood into the adjoining piece. The frass produced and placed in these tunnels by lyctid larvae is distinct because it is of the finest consistency of any powderpost beetles.

The larval stage lasts from two to nine months, depending on environmental conditions and the quality of wood they are in. By the spring following egg laying, larvae are mature. Mature larvae are less than $\frac{1}{4}$ inch long, C-shaped, yellowish white, wrinkled, and grublike, with an enlarged thorax (area just behind the head) and a small scattering of light-colored hairs on the body. The head is slightly pigmented with darker mandibles (jaws). They have six legs close to the head (Figure 3-11).

When mature, larvae tunnel just beneath the surface of the wood to construct a pupal chamber. They transform into the pupal stage inside this chamber. The pupal period lasts 12–21 days, after which the adult beetle emerges from the pupa and chews a circular exit hole to the surface with a diameter of 0.8–1.6 mm. Female beetles then mate and produce the next generation of eggs. Eggs may be laid in the surface pores of the wood around exit holes from which beetles have emerged.

The duration of the entire life cycle for most lyctid beetles is 9–12 months. However, indoors lyctid powderpost beetles may require two or more (possibly up to five) years to complete their development and emerge from the wood. The exact amount of time depends on the quality of the wood (primarily starch content), moisture and temperature.

Feeding and infestation

Hardwoods are preferred by lyctids, especially the ring-porous species of oak, hickory and ash. The outer sapwood layer is most preferred because it has larger pores than the inner heartwood. More diffuse-porous hardwoods such as walnut, pecan, poplar, sweet gum and wild cherry, as well as some tropical hardwoods, are also suitable if moisture content is between 8 percent and 32 percent. The greatest activity occurs in wood with moisture between 10 percent and 20 percent. This level of moisture is common in milled, partially seasoned, and fully seasoned lumber and is also found in most furniture, baskets, hardwood trim and flooring.

Since female lyctids will lay eggs in pores around emergence holes, reinfestation of structural wood is a

possibility — even in finished wood. Infestations that start in furniture or other locations within a home can spread by reinfestation or by larvae chewing their way from one piece of wood to adjacent pieces of susceptible wood. The length of time until an infestation is discovered varies based on drying method, wood age and the beetle life cycle. Since the life cycle can take up to five years in structural wood, infestations may not be detected for several years after the completion of a new home. You can distinguish true powderpost beetle exit holes from powderpost beetle exit holes using the ballpoint pen test. A standard ballpoint pen will not fit into the exit holes of true powderpost beetles.

False powderpost beetles

Identification

About 60 species of beetles in the family Bostrichidae are referred to as false powderpost beetles. This name distinguishes them from the “true” powderpost beetles.

A typical adult bostrichid beetle found infesting wood indoors is $\frac{1}{8}$ to $\frac{1}{4}$ inch long, reddish brown to black, elongate and cylindrical. They are stouter than true powderpost beetles and the head projects downward, being hidden by the pronotum (the area just behind the head). The pronotum is typically rough or rasplike along the front edge (Figure 3-12). Their short, straight antennae have three or four enlarged, saw-toothed terminal segments. The wing covers are concave at the posterior end, and in some species have spines projecting from these indented areas. The wing covers also have rows of pits along their surface and some species, have spines or jagged margins along the rear portion of the wing covers.

One unusual bostrichid is the black polycaon (Figure 3-13). This species is coal-black, cylindrical, and $\frac{1}{2}$ to 1 inch (12 to 25 mm) long. This species may be confused with the lyctids because the head is not covered by the oval pronotum, which gives it a somewhat more elongated appearance. However, its large size should help distinguish it from the true powderpost beetles.

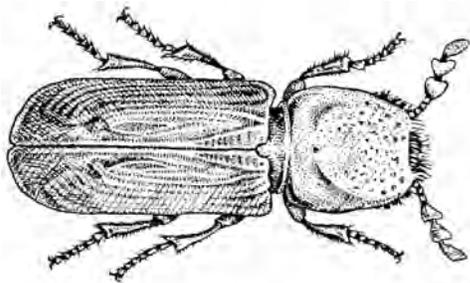


Figure 3-12. False powderpost beetle adult. Their head projects downward and their short, straight antennae have three or four enlarged, saw-toothed segments at the end. The wing covers have rows of pits and are usually concave at the posterior end.

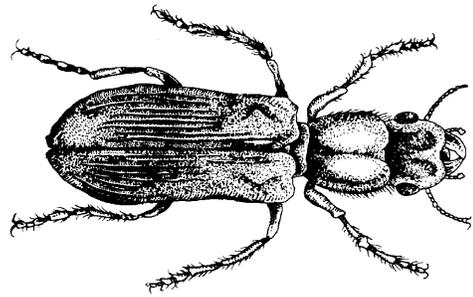


Figure 3-13. Adult black polycaon beetle. This false powderpost beetle has unique body features. It is $\frac{1}{2}$ to 1 inch long. The head does not project downward. Its large size should help distinguish it from true powderpost beetles.

Biology and behavior

Adult bostrichid wood borers are active primarily during the summer months. Many of the adults are visibly active during the day. However, the black polycaon may become a nuisance at night when attracted to lights in large numbers.

Rather than laying eggs on the wood surface as do other powderpost beetles, female bostrichids bore into the wood to prepare “egg tunnels” for laying eggs. The entry holes range in diameter from $\frac{3}{32}$ to $\frac{9}{32}$ inch (2.5 to 7 mm). Slender eggs are inserted into the wood pores exposed by these cross-grain tunnels. Adult beetles feed on the wood when preparing egg tunnels and mate only after the tunnels are at least partially completed.

After hatching, larvae (Figure 3-14) molt several times as they mature and increase the size of their tunnels to accommodate the growth. There are no pellets in the sawdust-like frass that they produce and pack into the tunnels behind them. The larval stage is usually completed by the spring of the year following egg laying. By this time, pupal cells are formed just beneath the wood surface and the larvae molt into pupae within these cells.

Adults later emerge from the pupae and chew an exit hole with a diameter of 3.0-7.0 mm to the surface. The tightly packed frass from their tunnels does not fall from the exit holes when the adults emerge, as it does from those of other powderpost beetles.

Several small species infesting freshly sawn softwoods can reach maturity in one year, but others require up to five years, depending on whether the wood dries rapidly. There are also records of the black polycaon emerging from wood 20 or more



Figure 3-14. False powderpost beetle larva. They are less than $\frac{1}{4}$ inch long, C-shaped, and yellowish white in color, with an enlarged area and six legs behind the head. The frass they make is tightly packed and, unlike that of other powderpost beetles, does not fall from the exit holes after the adults emerge.

years after the infested piece was incorporated into a structure.

Feeding and infestation

Bostrichids nearly always feed in the sapwood, particularly the outer portion, because of its relatively high starch content. Starch is readily digested by bostrichids, whereas cellulose cannot be digested. Most species are active in hardwoods, but a few infest conifers and bamboo, which are softwoods. Most infest freshly cut, partially seasoned wood with the bark still on, but some can attack more seasoned wood. Indoors, unfinished floors, window sills, furniture and bamboo items are especially susceptible to attack.

Furniture powderpost beetles

Identification

Most of the 299 species in the beetle family Anobiidae are wood borers. This entire group is often characterized by the behaviors of a few species. One species was ascribed the moniker “deathwatch beetle” during the Middle Ages by those who were awake during the night caring for people on their deathbeds. The name came from the persistent tapping sound associated with mating heard by these people during the quiet of the night. Many species in this family have been referred to as furniture powderpost beetles, though they infest structural wood as well.

Adult anobiids are reddish brown to near black, $\frac{1}{8}$ to $\frac{1}{4}$ inch (3 to 7 mm) in length, and elongated with a convex shape and 11-segmented antennae (Figure 3-15). The hoodlike pronotum completely conceals the head when viewed from above. Most have noticeable grooves and rows of pits on their wing covers. Some have short, light-colored hairs covering their bodies.

Biology and behavior

Many anobiids are nocturnal. Adults live only a few weeks. During this time, adult females mate and lay eggs on the surface of susceptible wood, usually concealed under splinters or debris, and in cracks or

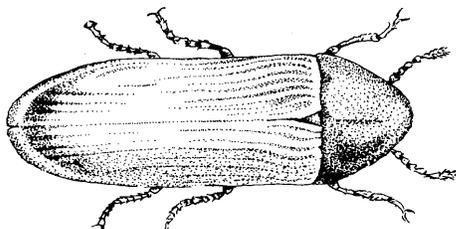


Figure 3-15. Furniture powderpost beetle. Adults are small, reddish brown to near black in color, convex in shape, with 11-segmented antennae and rows of pits on the body. A hoodlike area behind the head conceals the head when viewed from above.

old exit holes. Females of most species lay fewer than 50 eggs at a time. Eggs have a high survival rate and hatch into C-shaped, grublike larvae, which are white (except for the yellowish brown head and mouthparts) and hairy, with rows of small spines on the top of most segments (Figure 3-16).

Decayed wood presents ideal conditions for larvae to thrive. Many larvae die before boring into the outer sapwood, where they obtain food and protection from predators. Larvae that survive drill into the wood a short distance, then turn at a right angle and begin to create tunnels in the direction of the wood grain. They molt many times and grow along the way, enlarging the tunnels to accommodate their growth. Tunnels of many larvae intersect inside the wood,

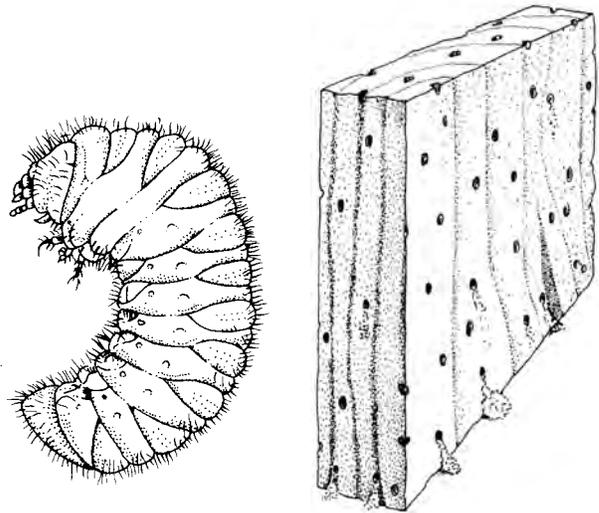


Figure 3-16 (left). Furniture powderpost beetle larva. Grublike C-shaped larvae are white with a yellowish brown head and dark mouthparts. They have six legs and are hairy, with rows of small spines on the top of most segments

Figure 3-17 (right). Furniture powderpost beetle damage. Tunnels intersect inside the wood, resulting in a mass of coarse, powdery frass that contains bun-shaped fecal pellets. The tip of a standard ballpoint pen will fit into these exit holes.

resulting in a mass of coarse, powdery wood debris (frass), and bun-shaped fecal pellets, which the larvae pack behind them as they tunnel (Figure 3-17).

Before molting from the larval to pupal stage, which usually occurs during spring, larvae enlarge a portion of the tunnel just under the surface of the wood and clear the area of frass. Adults emerge from the pupal stage, remain in the pupal chamber for a short time, then chew an exit hole, leave the wood, and immediately seek a mate. Development from egg to adult lasts two to three years, or even longer, depending on moisture content, food value of the wood cells, and temperature.

Feeding and infestation

The wood-boring anobiids require high moisture content, generally over 12 percent. They develop successfully in humid conditions, in moist, poorly

ventilated areas such as crawl spaces, basements, garages and utility sheds. In particular, untreated, unfinished wood is most susceptible. Some species attack both hardwoods and softwoods, while others attack just one wood type. Maple, beech, poplar and pine are especially susceptible. Damage is most severe in hardwoods, since nitrogen content is high. They feed primarily on the sapwood, although adjacent heartwood may also be damaged. Unlike other wood-boring beetles, anobiids can digest cellulose with the aid of yeasts in their digestive tracts. However, starches, sugars and proteins in the wood cells are the primary source of nutrients.

Initial infestations indoors may occur as a result of beetles flying in from outdoors, from being carried in on firewood, or by spreading from invaded lumber. After mating and fertilization, females commonly lay eggs at exit holes. This behavior contributes to reinfestation of the wood from which they emerged, so infestations may spread upward into walls and upper levels of a structure from the initial infestation point. Their damage to furniture in modern times has been lessened by the use of home heating systems that maintain lower humidities indoors and keep the wood dry.

The exit holes of powderpost beetles are 1.6–3.0 mm in diameter. You can distinguish powderpost beetle exit holes from true powderpost beetle exit holes using a ballpoint pen test. The tip of a standard ballpoint pen will fit into the exit holes of powderpost beetles but won't go into the exit holes of true powderpost beetles.

Bark beetles

Identification

Most of the 600 known species of bark beetles in the family Scolytidae are similar in appearance, life cycle and type of damage they cause. They get their name because they live just under the bark and do not penetrate deeply into the wood. Bark beetles generally infest live trees, but some are also attracted to recently cut logs that are still moist and covered by bark.

Adult beetles typically are no more than $\frac{1}{8}$ inch (3 mm) long, cylindrical, hard-shelled, and usually brown, reddish brown or black. The head is not visible from above because it is concealed underneath the front of the body (pronotum). The antennae have 11 or 12 segments with the first segment at the base being large and also the last three or four segments being fused together to form one enlarged segment called a club (Figure 3-18).

Biology and behavior

Adult bark beetles bore down through the bark just to the surface of the wood beneath. They feed on cambium, a thin layer of growing cells between the

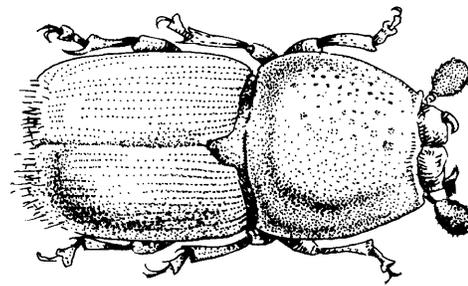


Figure 3-18. Bark beetle. Adults are very small, cylindrical, hard-shelled, and usually brown, reddish brown or black. The head is not visible from above and the antennae have the last three or four segments fused together to form one large segment called a club.

bark and the wood. Here adult females hollow out a short tunnel and chew small notches along the margin in which to lay their eggs. Larvae (Figure 3-19) that hatch burrow away from the main tunnel and create a network of distinctive fan-shaped gallery systems as they feed on the living cell layers between the surface of the wood and the bark (Figure 3-20).

As larvae mature, tunnels become enlarged and tightly packed with frass. At maturity, larvae pupate in the ends of the tunnels, and adults later emerge from these pupae and chew their way out to the surface of the bark. This results in buckshot-type exit holes that are $\frac{1}{16}$ to $\frac{1}{8}$ inch (1.5 to 3 mm) in diameter. Adult males and females fly away to locate suitable tree hosts in which to mate and lay eggs for the next generation. There can be as many as six generations per year, depending on environmental conditions and species.

Feeding and infestation

The only time live bark beetles will be observed indoors is when they've come from firewood that was

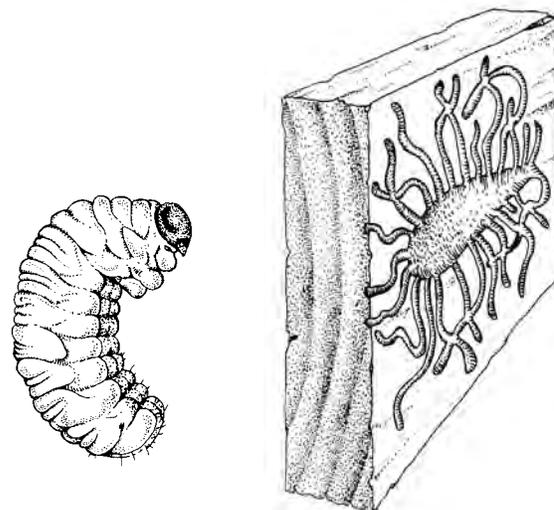


Figure 3-19 (left). Bark beetle larva. Larvae are C-shaped and legless with a dark head.

Figure 3-20 (right). Bark beetle damage. The central burrow with radiating lateral branches is only constructed under the bark on the surface of the wood.

brought indoors. Logs and furniture with their bark left intact could potentially support an infestation for a short period of time after the wood is cut. Some species may even survive for a year under the bark of either hardwoods or softwoods.

Because they feed on the surface of the wood, there is usually no concern about weakening of infested timbers. Once wood is dry, bark beetle activity ceases. They do not infest seasoned wood, so there is no need for concern about reinfestation.

Ambrosia beetles

Identification

Some members of two different families, Scolytidae and Platypodidae, are called ambrosia beetles because of bluish black stains that appear in wood they've infested. All but one species of ambrosia beetles belong to the family Scolytidae. Most species of Scolytidae are reddish brown to black as adults and about $\frac{1}{8}$ inch long. They are all cylindrical in shape. The head is not visible from above because it is concealed underneath the front of the body (pronotum). The antennae have 11 or 12 segments, the first of which is enlarged at the base and the last three or four of which are fused together to form one enlarged segment called a club.

The one Platypodidae species, *Platypus wilsoni*, is about $\frac{1}{4}$ inch long, thin and flattened. The brown body is covered with long yellow hairs. The head is visible from above and has antennae with a large, conspicuous, bulbous segment at the end (Figure 3-21).

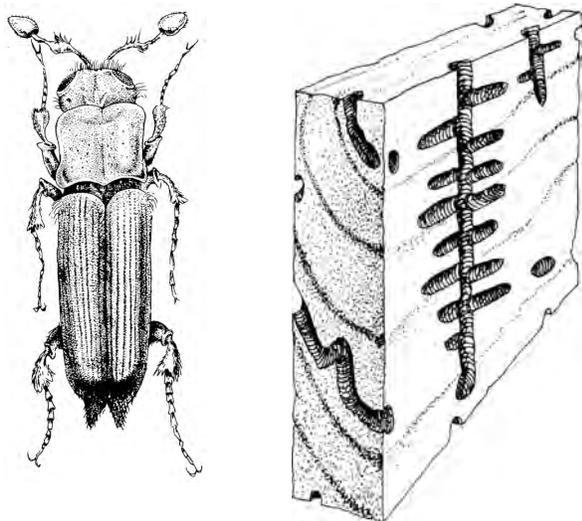


Figure 3-21 (left). Ambrosia beetle adult (*Platypus wilsoni*). The head is visible from above and has 11 or 12 antennal segments, the last three or four of which are fused together to form a club.

Figure 3-22. Ambrosia beetle damage. The tunnel is straight with lateral branches that proceed in a straight line or follow the curvature of the wood rings. There is a bluish black stain that appears in the wood from a fungus that grows in the tunnels.

Biology and behavior

Ambrosia beetle adult females attack softwoods or hardwoods that are covered by bark and where moisture content is higher than 30 percent. They carry fungal spores with them in special pouchlike structures associated with their exoskeleton. The female bores deep into sapwood, turns and, depending species, proceeds either in a straight line or follows the curvature of the annual rings (Figure 3-22). Some species also extend galleries into the heartwood. Along the way, she infects the wood with the fungal spores she carries.

Eggs are deposited along the tunnel, or sometimes short galleries called "cradles" are excavated along the sides of the main gallery. There also may be short side tunnels of the same diameter that follow the grain. Fungal spores are extruded along the main tunnel and into each cradle. As the fungus grows, it leaves a stain in the wood that is typically bluish black, but occasionally may be brownish. Each beetle species cultivates its own species of fungus, which is passed from one generation to the next. Several generations of beetles continue to expand the galleries as long as the wood remains sufficiently moist to sustain fungal growth.

When the eggs hatch there is plenty of threadlike fungus to nourish developing larvae. Larvae remain in the tunnels created by the adult female and eventually pupate. After emerging from the pupa, adult ambrosia beetles exit through the original entry hole.

Feeding and infestation

Freshly cut lumber may be attacked while it is stacked and before it has dried. The small holes, characteristic stain and network of galleries are especially common in birch, maple and oak. Tunnel diameter varies from $\frac{1}{50}$ to $\frac{1}{8}$ inch (0.5 to 3 mm). Ambrosia beetles do not ingest the wood they chew when making tunnels. Instead, the fine wood dust that results from their chewing is swept out of the tunnels by the females and collects in bark crevices or beneath entrance holes. It matches the color of the sapwood, which is light brown to bright white.

Prevention and control

When considering prevention and control of wood-boring beetles, differences in their wood preference and reinfestation habits must be examined (Table 1). Most wood-boring beetle infestations can be prevented by dry conditions. Since many species need a window of opportunity that occurs between when the wood is cut and when it is dry, egg-laying and infestation can be prevented for the most part. Therefore, the greatest responsibility for preventing wood-boring beetle infestations in structural timbers lies in the hands of those who mill and sell structural wood. They have the responsibility of drying wood

Table 1. Characteristics of wood-damaging beetles.

Beetle family	Adult appearance	Wood preferences	Characteristic damage
Lyctidae: true powderpost beetles	<i>Shape:</i> Somewhat flattened, head projecting forward. <i>Size:</i> 3–7 mm long. <i>Color:</i> Reddish brown to black.	Hardwoods. Sapwood. Prefer newer lumber. Will reinfest.	<i>Exit holes:</i> 0.8–1.6 mm in diameter. Early damage along the grain of the wood but later may reduce entire sapwood to powder. <i>Frass:</i> fine powder that readily sifts out. No pellets.
Bostrichidae: false powderpost beetles	<i>Shape:</i> Cylindrical, head directed downward, covered by spiny thorax. <i>Size:</i> 3–6 mm long. <i>Color:</i> Reddish brown to black.	Hardwoods. Sapwood. Will occasionally attack softwoods. Rarely reinfests.	<i>Exit holes:</i> 3–7 mm in diameter. Occasional tunnel going across the grain. <i>Frass:</i> Fine or coarse, which tends to cake. Few, if any, pellets.
Anobiidae: furniture beetles	<i>Shape:</i> Cylindrical, head directed downward and covered by hoodlike thorax <i>Size:</i> 3–7 mm long. <i>Color:</i> Reddish brown to black	Hardwoods and softwoods. Sapwood. Heartwood. Seasoned wood. Will reinfest.	<i>Exit holes:</i> 1.6–3.0 mm in diameter. More advanced galleries running across the grain. <i>Frass:</i> contains elongate or bun-shaped pellets.
Cerambycidae: longhorned beetles (old house borer)	<i>Shape:</i> Somewhat flattened, antennae half the length of the body. <i>Size:</i> 16–25 mm long. <i>Color:</i> Grayish black to brown with two bare spots directly behind head and two white patches on wing covers.	Softwoods. Sapwood. Seasoned wood. Contrary to its name, it prefers newer wood but may be found in old buildings. Will reinfest.	<i>Exit holes:</i> 6–10 mm in diameter. Extensive tunnels by larvae that avoid feeding all the way out to external surfaces. <i>Frass:</i> powderlike, containing many barrel-shaped pellets.
Buprestidae: metallic wood-boring beetles	<i>Shape:</i> Somewhat flattened and boat-shaped, wing covers are usually ridged or roughened. <i>Size:</i> 6–25 mm long. <i>Color:</i> Usually dark colored with a metallic sheen.	Hardwoods and softwoods. Sapwood. Heartwood. Unseasoned wood. Will not reinfest.	<i>Exit holes:</i> 2–10 mm in diameter. Extensive, flat, winding tunnels, packed with frass. Walls scarred with transverse lines. <i>Frass:</i> Sawdust-like, containing pellets.

properly so as to minimize the threat of infestation during cutting, stacking, milling and transport. They also play a large role in inspecting wood for signs of infestation before it is sold.

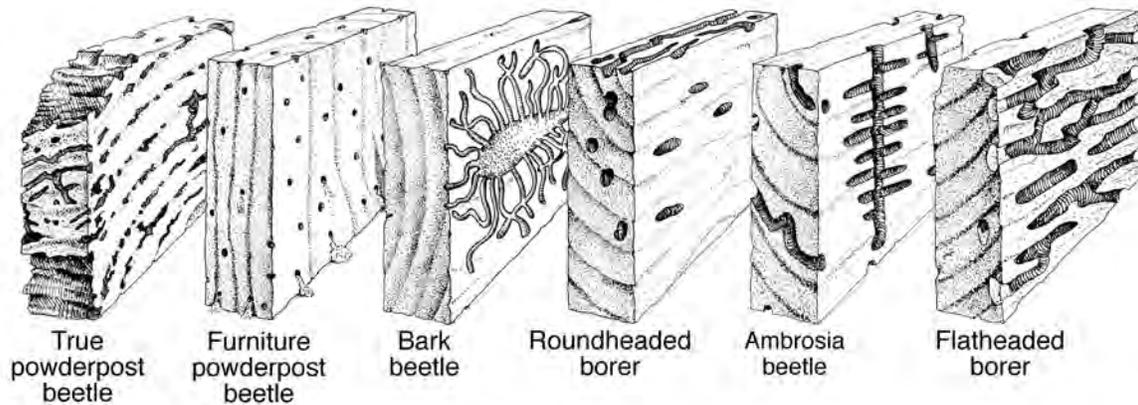
Sealing as many surfaces as possible with paint, varnish or polyurethane clogs wood pores and precludes egg laying on or near surface layers. Since sealing all structural timbers is excessive, chemically treating them is cost-prohibitive, and fumigation does not protect against reinfestation, measures to reduce moisture content are recognized as effective deterrents to beetle activity. These include proper ventilation in attics and crawl spaces, leak-free drainage, consistent heating and cooling and maintaining clearance between wood and soil. Any firewood is best stored away from the house, and the bark should be removed before it is brought indoors for use.

Even with all precautionary measures taken, larval activity can remain undetected in wood. It is important to know whether the identified wood borers are reinfestors. If not, all that is needed is to replace damaged wood. If they are reinfestors, a variety of solutions are available for different levels of damage. Applying polyurethane, paint or varnish will prevent reentry. Bringing the moisture content of wood to a level that is not conducive to the subsistence of beetles by the use of vapor barriers, ventilation and

central heat is an overall control measure that is also effective, given sufficient time. A more immediate strategy is the direct use of a portable heat source that maintains the wood at a temperature of 120 degrees F for at least 30 minutes to kill all developmental stages of the beetles. An instrument that delivers an electrical current through the wood is useful for infestations within paneling or other wood that can't be removed and replaced. Various chemical control applications are also available either as a spray, paint-on method or fumigation process.

When insecticides are sprayed or painted onto the surface of infested wood, it will take an extended length of time for all stages of beetle development to be affected. On unfinished wood, after the damaged area is completely cleaned of frass, an insecticide can be applied in two successive coats, the second before the first is dried. Finished wood usually does not allow penetration of insecticides, so it is the unfinished area (i.e., exit holes, crevices and open joints) where treatment can be applied into the wood using a syringe to inject a liquid insecticide.

Fumigation under a tarpaulin is a quick, complete method to exterminate wood-boring beetles but is expensive and does not offer a residual guard against reinfestation. Small items, such as furniture, can be fumigated in isolation and then refinished.



Study questions

Chapter 3 - Beetles

1. Beetles undergo complete metamorphosis in their life cycle, which means there are four stages of development.
 - A. True
 - B. False
2. Wood-boring beetles normally lay their eggs on the surface of the wood.
 - A. True
 - B. False
3. Roundheaded borers will reinfest structural wood because of its dryness.
 - A. True
 - B. False
4. Select the statement that is *not* true of the flat-headed borer.
 - A. When they hatch, the larvae bore under the bark into sapwood and heartwood.
 - B. They carve perfectly round, winding tunnels in the wood.
 - C. The walls of the tunnels in the wood are scarred with fine lines that run clockwise.
 - D. Mature larvae construct an elongated pupal cell just beneath the surface of the wood.
5. You can distinguish true powderpost beetle exit holes from powderpost beetle exit holes using the ballpoint pen test. The tip of a standard ballpoint pen won't fit into the exit holes of true powderpost beetles.
 - A. True
 - B. False
6. Rather than laying eggs on the wood surface as do other powderpost beetles, female false powderpost beetles bore into the wood to prepare "egg tunnels" for laying eggs.
 - A. True
 - B. False
7. Select the statement that is *not* true of the bark beetle.
 - A. Bark beetles generally infest live trees.
 - B. Bark beetles live just under the bark of the tree.
 - C. Adult bark beetles are $\frac{3}{8}$ to $\frac{1}{2}$ inch in size
 - D. Bark beetles do not infest seasoned wood.
8. Most wood-boring beetle infestations can be prevented by dry conditions.
 - A. True
 - B. False

ANTS AND BEES

Ants and bees belong to the insect order Hymenoptera, the order that also includes wasps. This insect order is large, containing more than 100,000 different species worldwide. Based on their diverse and complex behaviors, the Hymenoptera are usually considered to be the most advanced group of insects. Many species in this group are considered to be beneficial as pollinators of plants or predators of insect pests. There are, however, some pests in this group. Most of the pests attack living trees, but there are some pests that also attack wood used for construction. The most common structure-infesting Hymenoptera are carpenter ants and carpenter bees.

Carpenter ants

Identification

Carpenter ants are grouped together in the genus *Camponotus*, which includes 25 of the more than 500 species of ants in the family Formicidae. They are called carpenter ants because they damage wood. All carpenter ants are recognized by their characteristic evenly rounded thorax when viewed from the side (Figure 4-1). The species most commonly observed in the Midwest is the all-black species *Camponotus pennsylvanicus*. Colonies of this species contain 15,000 to 20,000 individuals. Four species of carpenter ants commonly occurring in the Midwest

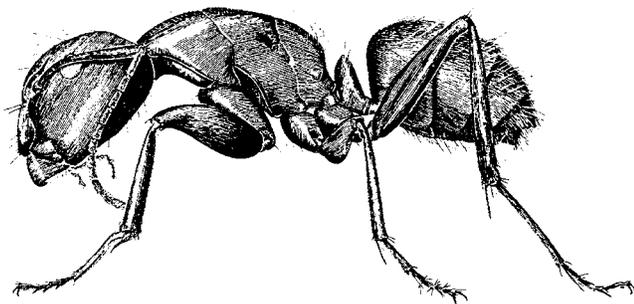


Figure 4-1. Carpenter ant. Carpenter ants can be identified by their characteristically rounded thorax as viewed from the side.

are *Camponotus castaneus*, *Camponotus ferrugineus* (both reddish in color), *Camponotus nearcticus* (uniformly dark brown), and *Camponotus sayi* (head, thorax, legs reddish, abdomen dark brown to black). Colonies of these species typically contain 3,000 to 4,000 individuals.

Carpenter ants are social insects, living in organized colonies, within which there are various types called castes. Castes are identified by their function within the colony. Adult stages in a carpenter ant colony include variously sized wingless workers, a wingless, egg-laying queen, and, during certain seasons of the year, many winged males and females called alates. Winged females approach $\frac{3}{4}$ inch (18 mm) in length from the head to the tip of the wings when folded along the back. Winged males are smaller and only grow to $\frac{7}{16}$ inch (11 mm) in length. The lone functional wingless queen in the colony grows to $\frac{9}{16}$ inch (14 mm) in length. There are several sizes of workers, the minor workers being the smallest, averaging $\frac{5}{16}$ inch (8 mm), the major workers up to $\frac{7}{16}$ inch (11 mm) (Figure 4-2).

Winged ants can be confused with winged termites unless you know which characteristics to

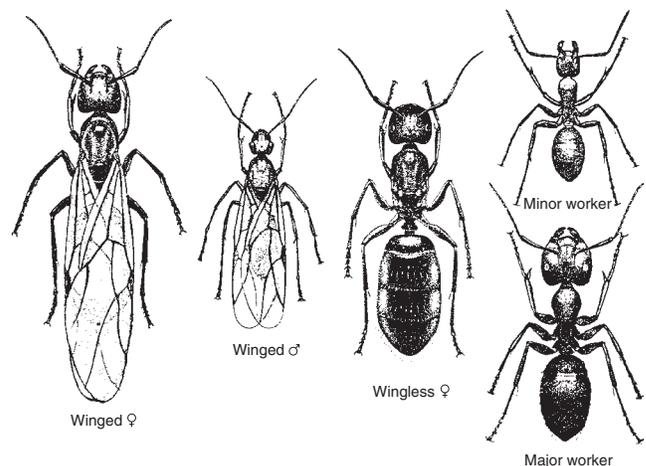


Figure 4-2. Carpenter ant workers. Carpenter ant colonies include several castes identified by their functions in the colony. The worker class includes individuals of various sizes.

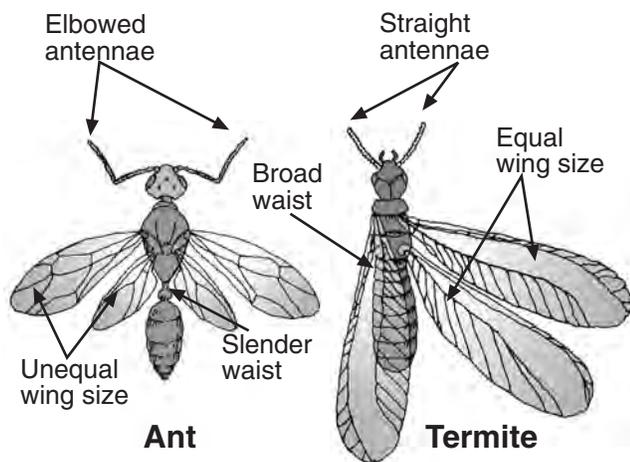


Figure 4-3. Comparison between termite and ant swarmer. All ants have narrow waists. The front wings of ant alates are larger than those in back. Ant antennae, unlike those of termites, have an angled appearance.

examine. All ants, including winged forms, have a narrow, pinched waist. This feature distinguishes them from termites. In addition, the relative sizes of the front and rear wings will help you distinguish winged ants from winged termites. The front wings of ant alates are much larger than those in back, while the front and rear wings of termite alates are equal in size (Figure 4-3).

Biology and behavior

When environmental conditions are conducive to “swarming,” large numbers of winged male and female carpenter ants emerge simultaneously from established colonies in an area. This occurs sometime between early spring and midsummer over a period of several days. The response of winged ants in different colonies to similar environmental conditions helps to synchronize swarming so that individual ants can breed with ants of another colony. Males form large mating swarms into which females fly and mate while in flight. Males die shortly after mating while females drop to the ground and search for places to establish new colonies. They chew off their wings sometime during the time they are searching out new nesting sites.

The mated female burrows into hardwoods or softwoods to nest. She locates a natural cavity in wood, or excavates one herself, then seals herself inside with a wood-fiber mixture. She lays her first brood of 15 to 20 eggs within a few days. The larvae that hatch out three weeks later are small, legless, white and grublike. The queen cares for the helpless larvae and feeds them with a fluid secreted from her mouth. She doesn’t leave the brood chamber or take nourishment during the two or more months required for the development of this first brood into workers. The resultant workers are all small but take over care for subsequent brood and the queen, enlarging the nest as the colony population

increases. From this time forward, the queen only lays eggs and doesn’t rear the offspring. Her eggs hatch into subsequent generations of workers that perform all the other tasks within the colony, and eventually, alates that will swarm and start new colonies.

The colony remains small during the first year and consists of the queen, 10 to 20 workers, and some larvae. For the next three to six years, the population grows until it numbers 2,000 to 3,000 individuals. After this, swarmers develop each summer, pass winter in the nest, then emerge the following spring or early summer. Workers are produced continually to replace those that die. Although a colony includes workers of various sizes, they are adults and therefore do not grow in size. Workers remain the same size from the time they emerge from the pupa until they die. Small workers do not grow into large workers.

Feeding and infestation

Large workers guard the nest, battle enemies and forage for food. They may travel up to 100 yards from the nest in search of food. Foraging activity is highest at night. Carpenter ants eat honeydew, which is sweet, partially digested tree sap that is made by plant-feeding insects — especially aphids. Worker ants gather honeydew and feed it to other colony members. Workers also scavenge for plant juices and the remains of dead insects. Inside houses, carpenter ants are drawn to sweets, meats, greases and fats. If the colony becomes stressed from lack of food and water, the queen and a few workers can survive by resorting to cannibalism.

Workers cannot ingest solid food and must carry it back to the nest to be transformed into liquid food. Food is brought to the nest and passed to smaller workers. The smaller workers feed solids to the larvae, which transform it into liquefied food. After food is located, transformed, liquefied, and regurgitated, it is then transferred mouth-to-mouth between colony members. The transfer of food is called trophallaxis.

Carpenter ants normally construct nests in hollow trees, logs, posts, and landscaping timbers outdoors. They prefer to establish nests in wood that is moist and rotting or that has been hollowed out by decay or by other wood-destroying organisms. They cut galleries along the grain of the wood, preferring the softer spring grain, leaving the harder summer grain, which serves as walls separating the tunnels. They cut openings in these walls to allow access between tunnels (Figure 4-4). Carpenter ants keep their galleries clean. They remove wood in the form of a coarse sawdust-like material, which they push from the nest. This often results in a cone-shaped pile accumulating just below the nest entrance hole. This pile may include other debris from the nest, including bits of soil, dead ants, insect parts and food remnants. Carpenter ants do not feed on wood.

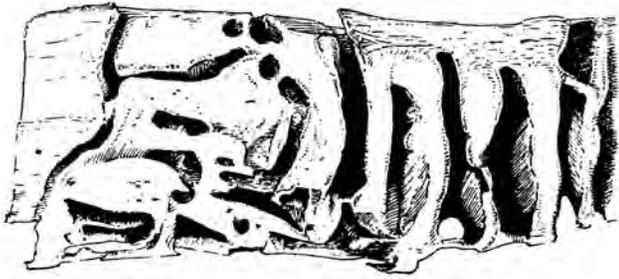


Figure 4-4. Carpenter ant tunnels. Carpenter ants construct galleries along the grain of wood in hollow trees, posts and timber. They do not feed on wood.

The nest consists of a “main” colony where the egg-laying queen, workers, larvae, eggs, and alates (future queens with wings) are located. In addition, “satellite” colonies are formed where larvae, workers and alates can be found. The egg-laying queen does not reside in satellite colonies. The greatest concern with carpenter ants is the establishment of satellite nests in structural wood.

Carpenter ants enter houses both to nest and to forage. They gain access to the structure by following tree branches and power or telephone lines that are in contact with the house. They may also enter through cracks and crevices around windows and in foundation walls, through ventilation openings, heating ducts, air conditioners, and firewood. They establish nests in areas such as the roof trim, siding, rafters, joists, sheathing, decks, porches, steps, sills, subflooring, doors and window frames. They may also establish nests inside hollow areas, like hollow doors or small voids produced during construction. They can move from decaying wood into sound lumber when enlarging the nest. Most often, they establish nests in areas of the structure where wood is moist, or has been damaged by moisture.

Prevention and control

Preventing carpenter ant infestations begins by correcting conditions that lead to moist or water-damaged wood within a structure. Wood decay can be avoided by fixing leaking roofs, gutters and water pipes, maintaining clearance between wood and soil, allowing free-flowing drainage and ventilation and ensuring proper roof flashing and tight exterior wood joints. Wood that gets wet from time to time should be pressure-treated. Keeping logs, wood debris and firewood away from the immediate vicinity of the house also reduces risk. Seal exterior cracks and crevices through which ants could enter the structure.

The most important action to take is locating the primary nest where the queen lays her eggs and treating this nest directly. Though there may be satellite colonies established in structural wood, the parent colony is almost always located outdoors. Locating and tracing the foraging trail of worker ants can help

you to find the parent colony and egg-laying queen. The telltale frass, consisting of excavated wood, feces and dead ants, will help in locating the parent colony. Once located, a parent colony can be treated by drilling into the infested wood and injecting a dust or liquid insecticide into the galleries. Only those drill holes that penetrate the galleries should be treated. Multiple holes usually need to be drilled to find and treat the entire gallery system.

Satellite colonies in structural wood should also be located and treated. Indicators of infested wood include sightings of large, black, foraging ants when a light is turned on at night or piles of carpenter ant frass in which ant and other insect fragments are interspersed with wood fibers expelled from cracks, crevices or slits. Infested structural wood is treated by drilling into the wood and injecting a dust or liquid insecticide into the galleries. Multiple drill holes will help find and treat the entire gallery system.

Treatment strategies for satellite colonies found living in other areas of the structure include the following:

- Wall voids are treated by drilling a small hole into the wall directly above the baseboard and injecting aerosol or dust insecticide into the wall.
- Porch columns and window frames are treated by drilling a small hole into voids or infested wood and injecting insecticide dust.
- Eaves or soffits are treated by drilling holes into the wood where the ants are living and then injecting liquid or dust insecticide into the gallery system.
- Hollow doors are treated by drilling a hole into the void and injecting insecticide dust.
- Colonies under insulation are removed using a vacuum cleaner or treated using a nonresidual liquid insecticide.
- Colonies in hollow curtain or shower rods are removed with a vacuum and treated with a nonresidual liquid insecticide.
- Colonies in cardboard boxes or other containers are easily removed with a vacuum cleaner.

If you are unable to locate the primary or satellite nests, indoor foraging activity can be temporarily halted by liquid insecticide treatments around the perimeter of the structure. Applying a liquid insecticide to the soil, exterior foundation wall, and areas around doors and windows to form a barrier 1 meter high and 1 meter wide around the perimeter is an effective, but temporary deterrent. Remember, these treatments alone will not eliminate the infestation because the queen will continue to lay more eggs that hatch into workers who will forage into the structure once the insecticide barrier breaks down. Long-term

elimination of the colony is achieved only by locating the egg-laying queen and killing her.

If liquid or dust insecticide treatments are not successful, carpenter ant baiting is an option. Baits are ingested by the workers, conveyed back to the nest, and fed to the larvae and egg-laying queen. Since the type of bait carpenter ants will consume is unpredictable, a variety of types should be offered where ants are foraging so they will be able to choose the type they will eat. Replenish baits to keep them fresh. Baits can also be used in conjunction with liquid control methods but will not be effective if the bait is contaminated with liquid insecticide or if the bait is placed where it is isolated from the foraging workers by the liquid treatment zone.

Tips for successful use of baits

- Check the bait on the day after placement and then at least once a week to see if the ants have found and are noticeably feeding on it. If not, switch to a different bait. If feeding is evident, place additional baits.
- Place baits as close to the ant colony as possible next to a trail exiting a wall or crack in the slab.
- Ants like to trail along structural contours, so wherever possible, place baits along edges and corners of cabinetry, walls, cracks in concrete, landscape timbers, wires and plumbing.
- Place baits in electrical outlets in walls. Bait stations don't fit, so a gel ant bait inside a piece of plastic straw works well in this situation.
- Advise the customer to keep other food sources sealed and unavailable to the ants. This includes garbage cans.
- Place baits liberally to attract foraging ants from different colonies.
- Don't apply insecticides over bait placements and don't place baits on insecticide-treated surfaces.
- Place baits outdoors during warm weather.
- Be aware that some ant species are difficult, if not impossible, to bait.

Acrobat ants

Identification

Acrobat ants belong to the genus *Crematogaster*. There are 31 species of *Crematogaster* in North America. These ants range in size from 1/10 to 1/6 inch long and have 12-segmented antennae with a three-segmented club. Their color varies from light brown to black and they are sometimes multicolored. Individual ants of the same species can exhibit different colors in different habitats. They have two nodes in their thin waist and are further recognized by a single pair of spines at the rear of the thorax

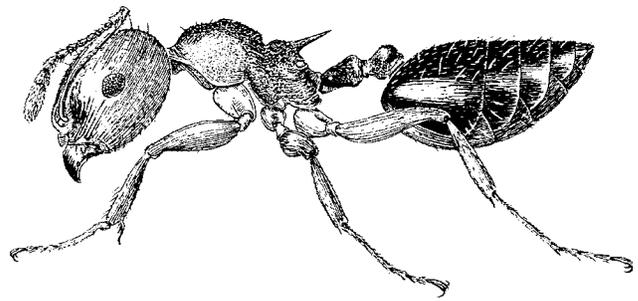


Figure 4-5. Acrobat ant. Carpenter ants can be identified by the two nodes in their waist and by the pair of spines at the rear of the thorax.

and a pointed, heart-shaped abdomen (Figure 4-5). Acrobat ants get their name from the way they hold their pointed, heart-shaped abdomens in a contorted position, with the rear of the abdomen facing slightly upward. This is due to the way in which the thin waist (petiole) attaches to the top of the abdomen instead of directly in the front.

Acrobat ants are social insects. They live in organized colonies. In the colony are various kinds of ants called castes. Castes are identified by their function. Adult castes in the colony include many uniformly sized wingless workers, a single wingless, egg-laying queen, and, from mid-May to late September, winged males and females called alates. Winged ants can be confused with winged termites unless you know which characteristics to examine. All ants, including winged forms, have a narrow, pinched waist. This feature distinguishes them from termites. In addition, the front wings of ant alates are much larger than those in back, while the front and rear wings of termite alates are equal in size. Winged ants have elbowed antennae, but termite antennae do not have this angled appearance (see Figure 4-3).

Biology and behavior

Little is known about acrobat ant biology and behavior. They nest primarily outdoors. Their outdoor nests are found in dead and decaying wood, in leaf litter, and in soil under rocks. Colonies are normally small, but large colonies containing thousands of workers can be found. When a large colony is disturbed, the workers defend the colony by giving off a strong odor and by biting and stinging. Interestingly, small colonies are usually timid when disturbed.

Feeding and infestation

Acrobat ants feed on a wide variety of foods. Both sweet and protein foods are eaten. They especially like to gather honeydew from aphids, mealybugs and scale insects. They often construct hideaways of plant or earthen materials in which to protect these aphids. Workers will scavenge for plant juices and the remains of dead insects. They also prey on various

insects, including termite alates, immature beetles and caterpillars. Indoors, they seem to prefer sweet foods. Workers carry food back to the nest and feed it to other colony members. This transfer of food between colony members is called trophallaxis.

The acrobat ant is primarily a nuisance pest, but may cause minor structural damage. They use shrub and tree limbs or power lines as pathways to get onto homes where they gain access through cracks and crevices. They usually enter the home through cracks and crevices around doors, windows, and along eaves. In structures, they are often found infesting wood that is moist or previously damaged by carpenter ants or termites. They usually nest in wood trim, doors, and especially door and window frames. They are also found in wall voids and in foam insulating boards behind siding.

Prevention and control

Prevention and control measures for acrobat ants are similar to those for carpenter ants. Preventing infestations begins by correcting conditions that lead to moist or water-damaged wood within a structure. Wood decay can be avoided by fixing leaking roofs, gutters and water pipes, maintaining clearance between wood and soil, allowing free flowing drainage, attic ventilation, proper roof flashing and tight exterior wood joints. Wood that gets wet from time to time should be pressure-treated. Keeping logs, wood debris, firewood, and tree or shrub branches from touching the house also reduces risk. Seal exterior cracks and crevices through which ants could enter the structure.

Locate the primary nest where the queen lays her eggs and treat this nest directly. Following the foraging trail of worker ants can help you to find the parent colony and egg-laying queen. Look for pieces of foam insulation in windowsills inside and along the foundation outside. This can indicate the presence of nests in foam in wall voids or behind siding. Look for workers on the ground along the foundation outdoors. Examine the branches of trees and shrubs that touch the structure. Inspect the eaves of the structure for ant trails and other signs of infestation including warped boards or peeling paint. A moisture meter can be used to find areas of high moisture. Fungus on the surface of the wood is also a good indicator of moisture. Check logs, stumps, firewood, etc. near the structure for acrobat ant activity.

Once located, a parent colony can be treated by drilling into the infested wood and injecting a dust or liquid insecticide into the galleries. Only those drill holes that penetrate the galleries should be treated. Multiple holes usually need to be drilled to find and treat effectively the entire gallery system.

Specific treatment strategies for colonies found living in the structure include the following:

- Wall voids are treated by drilling a small hole into the wall directly above the baseboard and injecting aerosol or dust insecticide into the wall.
- Porch columns, door and window frames and wood trim are treated by drilling small holes into the infested wood and injecting insecticide dust into the galleries.
- Eaves or soffits are treated by drilling holes into the wood where the ants are living and injecting liquid or dust insecticide into the galleries. Siding may be removed to expose colonies, which can be removed with a vacuum cleaner.
- Hollow doors are treated by drilling a hole into the void and injecting insecticide dust.
- Colonies in foam boards are removed with a vacuum cleaner and treated with a nonresidual liquid insecticide after the homeowner or a carpenter removes the siding.
- Remove or burn infested firewood.

Carpenter bees

Identification

Bees in the family Apidae that bore into wood to nest rather than into the stems of plants are called carpenter bees (Figure 4-6). They are in the genus *Xylocopa*. Carpenter bees resemble bumble bees, being blue-black, heavy-bodied insects, up to 1 inch (25 mm) long, with yellow or orange hair. The main difference from bumble bees in appearance is that carpenter bees have hairless, metallic, black abdomens while those of the bumble bees are hair-covered (Figure 4-7).

Biology and behavior

Carpenter bees behave differently than bumble bees. Male carpenter bees can be

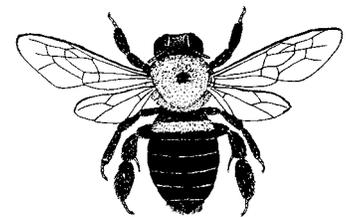


Figure 4-6. Carpenter bee. Carpenter bees have a black, hairless abdomen.



Figure 4-7. Bumble bee (left) and carpenter bee. Unlike bumble bees, carpenter bees hover near their nests in structures.

seen hovering in midair around their nests, and they investigate humans who enter their territory. They hover near active nests to defend their territory from other males and to mate with females who are emerging from nests. They buzz loudly and are fast flyers, sometimes ascending 60 feet (18 meters) in the air. Females are capable of stinging, but usually don't because they aren't aggressive. Stings result only if females are handled in some way. In contrast, bumble bees do not hover around structures. They commonly are found foraging for pollen and nectar at flowers.

Adult carpenter bees emerge from the pupal stage during the fall. After a brief period of activity, these young bees return to their tunnels to spend the winter. Upon emerging in early spring, these bees feed on nectar for a few weeks before mating. Females then begin nest preparations. They either excavate new galleries in exposed wood or clean out and expand previously constructed galleries. After several generations have used the same nesting site, tunnels become expansive and interconnected.

After constructing or cleaning out old galleries, the female places "bee bread" in the most distant part of a tunnel. Bee bread is a mixture of pollen, saliva and regurgitated nectar prepared by the female. The small loaf of bee bread is about the size of her abdomen. After preparing the bee bread, she lays an egg on it and then sections off the area with a wall of wood pulp she made by moistening chewed wood with saliva. She repeats the process up to six times, making approximately one brood chamber per day.

Eggs hatch into larvae that are white, legless and grublike. They remain inside the brood chamber throughout the entire larval and pupal stages. Pupae are light-colored early on but gradually darken as they age. After emerging from the pupal stage, newly formed adult bees remain in the brood chamber for a few days. They feed on the remaining pollen as their bodies and wings dry out. Development from egg to adult within the brood chamber takes from one to three months. In late summer or fall the adult bees finally emerge from the brood chamber. They remain in the vicinity of the galleries, feeding on whatever pollen and nectar they can find, until winter forces them back inside the galleries.

Feeding and infestation

Normally, carpenter bees start infestations within the suitable range of a current nesting site. Inspection of all structures within this area can tell you a lot about the location and extent of colonies. The male's hovering presence is the most obvious indicator of tunneling activity.

Carpenter bees prefer to tunnel in seasoned wood, especially woods that are easy to chew. Preferred woods include softwoods such as cedar, redwood, white pine, southern yellow pine, fir and cypress.

Hardwoods that are softened by weathering and are not protected by paints or stains are the most suitable nesting sites. The entry hole a female bores into this wood is perfectly round and ½ inch (12 mm) in diameter. It is often made in the bottom of an overhang. A coarse, sawdust-like frass drops from the entryway as the female uses her mandibles to bore this opening. Once the female has chewed into the wood for about the length of her body, she makes an abrupt turn at a right angle, and tunnels with the wood grain about 6 to 10 inches (10 to 15 cm). Previously burrowed galleries can be used year after year and have been measured extending 6 to 10 feet (2 to 3 meters) or farther (Figure 4-8).

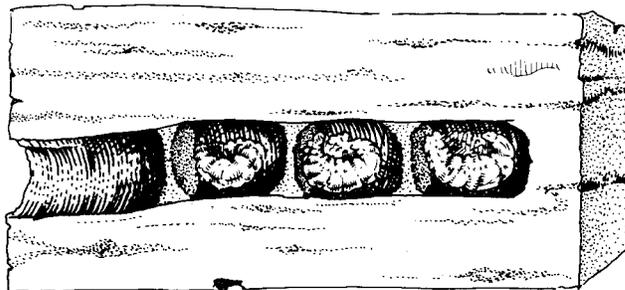


Figure 4-8. Carpenter bee tunnel and larvae. Carpenter bees prefer to tunnel in seasoned wood and reuse these galleries year after year.

Carpenter bees are drawn to well-lighted areas with protected locations where they can burrow. Any unpainted wood surface is susceptible to infestation. This includes structural wood, fence posts, utility poles, firewood and lawn furniture. Since structural wood is their preferred nesting site, the best way to prevent them from making the first entry hole is to apply an impenetrable coating of paint to all softwood surfaces. The same applies to exposed hardwoods that might become weathered, softened, and susceptible to attack. It usually takes several years of neglect for severe structural damage to occur from carpenter bee activity.

Prevention and control

Installing wood that has been painted or pressure-treated with preservatives will resist carpenter bee infestation. A surface coating of preservative is also an option, but the wood must be treated again as it weathers. However, in cases of both painted and preservative-treated wood, carpenter bees still have been known to invade.

Insecticide treatments of active nesting sites are best applied to the tunnel entrances after dark when the bees are inside and less active. Any insecticide dust labeled for bee control applied to the nest interior will remain there long enough to kill bees that come in contact with it after emerging from the brood chambers. Dusts containing boric acid have been

reported to be effective. Desiccants can also be used if they do not become wet. They are generally lower in toxicity to humans and other animals, but inhalation of desiccants can cause severe lung damage. Liquid formulations will also be effective against adult bees that are inside the nest in the fall if applied into the nest opening after they have already emerged from their brood chambers.

Treatments are most effective when applied as deeply into the holes as possible. Bees moving in and out of the nest will be killed if the holes are left unplugged for a few days following treatment. After

this, fill the holes with plastic wood, steel wool, caulk or copper gauze, followed by a wooden dowel plug or wood filler.

If a large population has not yet established, and no serious damage is evident, larvae and pupae can be killed while inside their brood chambers without using insecticide. To do this, simply insert a sturdy wire into the entrance hole and probe deeply into the tunnel, making sure to destroy all of the brood chamber walls and crush the larvae inside. In these new nests, nesting females can often be eliminated as well.

Study questions

Chapter 4 - Ants and Bees

1. Carpenter ants are social insects, living in organized colonies, within which they are various types called castes.
 - A. True
 - B. False
2. Winged ants can be confused with winged termites unless you know which characteristics to examine. An insect with a narrow, pinched waist and front wings much larger than those in back is which insect?
 - A. Ant
 - B. Termite
3. Only female carpenter ants will “swarm” when the environmental conditions are correct.
 - A. True
 - B. False
4. Carpenter ants prefer to establish nests in wood that is moist and rotting or that has been hollowed out by decay or by other wood-destroying organisms.
 - A. True
 - B. False
5. Long-term elimination of the carpenter ant colony is achieved only by locating the egg-laying queen and killing her.
 - A. True
 - B. False
6. Satellite carpenter ant colonies can be found living in the following areas:
 - A. Cardboard boxes
 - B. Hollow curtain/shower rods
 - C. Under house insulation
 - D. Wall voids
 - E. All are correct
7. Carpenter bees bore into wood to nest.
 - A. True
 - B. False
8. Carpenter bees will behave in the following ways:
 - A. Male carpenter bees can be seen hovering in midair around their nests.
 - B. Female carpenter bees are aggressive.
 - C. Male carpenter bees buzz loudly and may ascend to 60 feet in the air.
 - D. A and C are correct
 - E. All are correct
9. Select the statement that is *not* true of carpenter bees.
 - A. Carpenter bees prefer to tunnel in seasoned wood.
 - B. The entry hole a female bores into this wood is perfectly round and ½ inch in diameter.
 - C. Carpenter bees are drawn to well-lighted areas with protected location where they can burrow.
 - D. It usually takes several years of neglect for severe structural damage to occur from carpenter bee activity.
 - E. All of the above are correct

5

FUNGI

Fungi make up their own kingdom of living organisms, separate from plants and animals. Unlike plants, they neither contain nor play any part in the production of chlorophyll. Fungi are classified according to the way they obtain nutrients from their surroundings.

Dustlike fungal spores germinate on suitable feeding substrates in the presence of oxygen within a temperature range of 40 to 100 degrees F and at least 20 percent moisture in the substrate. Germination of spores leads to the production of hyphae, or microscopic threads, that penetrate the substrate and release digestive enzymes. Branching mycelia grow from the original hyphae, digesting the substrate and fanning out in threadlike strands. The digested substrate is absorbed by the mycelia as a nutrient source.

Wood-decay fungi

When spores germinate on structural wood, these fungi can cause the wood to change chemically, decay, lose strength, soften, and become discolored or stained. The primary components that are digested in wood are cellulose, hemicellulose and lignin. Wood decay fungi are classified based on which of these components they digest and the resultant characteristics of the damaged wood.

There are hundreds of species of wood-decaying fungi that attack the sapwood and heartwood of most wood species. Since the hyphae are colorless, the early stages are not easily detected without a moisture meter. There are three important groups of wood-decay fungi — brown rot, soft rot and white rot.

Brown rot

Brown rot fungi break down cellulose and hemicellulose for food, leaving the brown residue of lignin. In North America, brown rot fungi are most common in conifers. They are closely related to mushrooms. Decay starts on the interior of the wood and causes the wood to weaken. Later, the external signs of infestation include dark brown discoloration, excessive

shrinkage, cross-grain cracks, and ultimately “wood” that can easily be crushed into a powder.

Some species of brown rot fungi called dry rot fungi thrive in humid, unventilated places where the wood is moist but not saturated. In the United States, the most common dry rot fungus is *Merulius lacrymans*. Dry rot spores germinate on the surface of wood whose moisture content is slightly above 20 percent. Poor or improper ventilation in areas that can retain heat provide this ideal environment.

Soft rot

Soft rot fungi break down cellulose and hemicellulose and may partially digest lignin. There are more than 300 species of known soft rot fungi that are often called molds. They thrive in high moisture and nitrogen conditions found in green wood. They cause softening of wood from outside inward to 3 or 4 mm in depth. The wood appears wet, spongy or pitted. Like brown rot, soft rot occurs only where a structure is in constant contact with moisture.

White rot

White rot breaks down cellulose, hemicellulose and lignin. In doing so, it bleaches out the wood, causing a whitened appearance, a gradual spongy consistency and weakening of the wood. This normally occurs with hardwoods, but can also affect some softwoods. There are often visible fungal structures present as well.

Wood-stain fungi

Wood-stain fungi do not cause structural damage, but when they are present on wood, they indicate that conditions are good for other wood-decay fungi to reproduce. Two types of wood-stain fungi are typically observed in structural situations. Sap-staining fungi produce blue hyphae and a blue discoloration that can be visible on new lumber as streaks, specks or patches. This discoloration persists, even after moisture is no longer present. Surface-staining fungi

produce colorless hyphae, but their fruiting bodies color the wood surface pink, yellow, orange, green, grey or powdery black. This mold can be brushed or washed off.

Wood-stain fungi can provide a food source for other structural insect pests, including *Ahasaverus advena*, the foreign grain beetle. When two-by-four framing is exposed to moist conditions during the building phase, growth of wood-stain fungus normally occurs. Eggs of *A. advena* are laid on the framing and the larvae feed on the fungal mycelium before pupation. The adults emerge later, normally from the walls after construction is complete, causing great concern for the new homeowners. The emergence of thousands of beetles occurs periodically until one annual cycle of heating and air conditioning is complete. This dries the wood sufficiently to eliminate the fungus and the insect that feeds on it.

Prevention and control

Removing the source of moisture eliminates the likelihood of fungal growth. Well-seasoned wood used in construction does not contain enough water to

support fungi. Proper protection of structural wood from moisture includes the following steps:

- Eliminate wood-to-soil contact.
- Fix leaky pipes, faucets and roofs.
- Keep water drained away from buildings by construction of roof overhangs, installing gutters, downspouts and drain tiles.
- Do proper grading before construction begins.
- Use dehumidifiers, air conditioners and heating systems to reduce moisture in the air.
- Ventilate crawl spaces and attics. A 1 square foot opening for each 25 linear feet should be installed in crawl spaces for proper cross ventilation.
- Install vapor barriers over the soil beneath a structure. This causes moisture to condense on the barrier and return to the soil instead of on flooring and joists.

After moisture sources are eliminated where, rotted wood should be removed and replaced with dry lumber. If the moisture source cannot be avoided, the use of pressure-treated wood or nonwood materials is essential.

Study questions

Chapter 5 - Fungi

1. Fungi can produce their own nutrition.
 - A. True
 - B. False
2. Wood-decay fungi can cause wood to change chemically and discolor.
 - A. True
 - B. False
3. The important groups of wood-decay fungi are as follows:
 - A. Brown rot
 - B. Soft rot
 - C. White rot
 - D. Red rot
 - E. All of the above are correct
 - F. A, B, C are correct
4. Which wood-decay fungus is closely related to mushrooms?
 - A. Brown rot
 - B. Soft rot
 - C. White rot
5. Which wood-decay fungus causes the wood to appear wet, spongy or pitted?
 - A. Brown rot
 - B. Soft rot
 - C. White rot
6. Wood-stain fungi do not cause structural damage to wood.
 - A. True
 - B. False
7. Can wood-stain fungi provide a food source for other structural insects?
 - A. Yes
 - B. No
8. Well-seasoned wood used in construction does contain enough water to support fungi.
 - A. True
 - B. False

APPENDIX A

GLOSSARY

- Abdomen** — The hindmost of the three main body divisions of an insect.
- Alate** — Winged form of insect
- Antennae** — A pair of segmented appendages located on the insect head above the mouthparts, that obtain sensory information.
- Bath trap** — Openings in the slab where the plumbing for the bathtub enters the house
- Borates** — Borate is a salt or ester of boric acid.
- Boric acid** — A boron compound used as an insecticide
- Buttress** — A short wall built perpendicular to the main outer wall of a building, supporting or appearing to support, the exterior wall.
- Cambium layer** — A layer immediately below the bark of a plant from which annual growth occurs.
- Cellulose** — The substance making up the cells walls of plants; wood fiber.
- Chitin** — Hard, but flexible, substance forming the outer covering of insects.
- Chlorophyll** — Green pigments in plants that facilitate photosynthesis.
- Desiccant** — A chemical agent that absorbs moisture, causing the outer body cover of insects to dry out.
- Drain tile** — A perforated, corrugated plastic pipe laid at the bottom of the foundation wall, used to drain excess water away from the foundation.
- Eaves** — The part of the roof which extends beyond the side wall.
- Elytra** — Hardened front wings that form a shell over the rear wings on beetles.
- Exoskeleton** — The hard outer covering that makes up the skeleton of insects
- Fascia** — A flat, horizontal board enclosing the overhang under the eave.
- Floating slab** — A floor surface that is not connected to the foundation wall.
- Footings** — Wide pours of cement reinforced with rebar (reinforcing bar) that support foundation walls, pillars or posts.
- Frass** — Debris or excrement produced by insects. **or** Wood fragments made by a wood-boring insect, usually mixed with excrement.
- Fungi** — Plural of fungus. A group of organisms that lack chlorophyll and obtain nutrients from dead or living organic matter
- Germinate** — To start or cause to start a process of growth or development
- Grub** — A type of insect larva that is curved (C-shaped), sometimes legless, and whitish in color.
- Heartwood** — The older, harder, nonliving central wood of a tree that has ceased to conduct sap and serves the sole function of support.
- Humus** — Nutrient-rich earth formed when plant material decays.
- Hydraulic cement** — a cement that resists moisture or hardens underwater
- Hyphae** — Threads that make up the body of fungi and penetrate the host for cellulose and lignin.
- Joists** — Any of the small timbers or metal beams ranged parallel from wall to wall in a structure to support a floor or ceiling
- Larvae** — Plural of larva; wormlike stage of insect development after the egg and before the pupa (cocoon) and adult.
- Lignin** — The binding agent that holds the cellulose fibers of wood cells together
- Mandibles** — The main grinding mouthpart of an insect.
- Membrane** — A pliable sheet of tissue that covers or lines or connects organs.

Metamorphosis — Change in insect form during development from egg to larva, often to pupa, to adult.

Molt — The shedding of skin before entering another stage of growth.

Monolithic slab — A continuous pour of concrete that includes the footings to create the floor surface and foundation walls of a structure.

Mycelium — The threadlike body of a fungus.

Order — In the scientific system of classification (taxonomy), the division between class and family.

Organophosphates — A class of organic pesticides containing phosphorus, which interrupts nerve impulses along the central nervous system leading to eventual death.

Parasitic — The act of living off of another organism without benefiting it in any way.

Phloem — Veinlike tubes that transport sugar and other nutrients from leaves where photosynthesis occurs to the rest of a plant.

Pilasters — A decorative, rectangular column attached to a wall, often so as to resemble a classical column.

Plate — A horizontal beam that provides bearing and anchorage for a structure.

Plenum — The air return path of a central air handling system; can be either ductwork or open space.

Polyurethane — A clear plastic coating.

Pronotum — Segment on the thorax just behind the head of an insect.

Prothorax — The front section of the thorax which includes the attachment point for the front legs.

Protozoan — A single-celled organism.

Pupate — To change from a larva to the inactive pupal stage in an insect life cycle.

Pyrethroids — Synthetic form of pyrethrins, an organic insecticide derived from chrysanthemums.

Rhizomorphs — Rootlike structures of fungi that act as water conductors.

Sapwood — The outer, youngest, lighter-colored layers of the tree, just beneath the bark, that conduct sap from roots to leaves.

Sill plate — The lowest member of a structural frame, resting on the foundation.

Soffit — The underside of a roof overhang.

Spore — The asexual reproductive cell of fungi.

Thorax — The midsection of the insect between the head and abdomen.

APPENDIX B

ANSWERS TO STUDY QUESTIONS

Chapter 1 - Inspections and Equipment

- 1(C)
- 2(A)
- 3(A)
- 4(A)
- 5(D)
- 6(A)
- 7(A)
- 8(B)
- 9(A)
- 10(B)
- 11(B)
- 12(D)

Chapter 2 - Termites

- 1(A)
- 2(A)
- 3(C)
- 4(B)
- 5(A)
- 6(B)
- 7(D)
- 8(B)
- 9(A)
- 10(A)
- 11(A)
- 12(A)
- 13(A)
- 14(B)
- 15(B)
- 16(B)
- 17(B)
- 18(D)
- 19(D)
- 20(A)
- 21(A)
- 22(B)
- 23(A)

Chapter 3 - Beetles

- 1(A)
- 2(A)
- 3(B)
- 4(B)
- 5(A)
- 6(A)
- 7(C)
- 8(A)

Chapter 4 - Ants and Bees

- 1(A)
- 2(A)
- 3(B)
- 4(A)
- 5(A)
- 6(E)
- 7(A)
- 8(D)
- 9(E)

Chapter 5 - Fungi

- 1(B)
- 2(A)
- 3(F)
- 4(A)
- 5(B)
- 6(A)
- 7(B)

Emergency Telephone Numbers

Regional Poison Center

1-800-222-1222

For pesticide poisoning emergencies, state poison centers provide service that is free of charge to the public and is available 24 hours a day, seven days a week.

Environmental Emergency Response

For pesticide spill emergencies

Iowa - Iowa Department of Natural Resources	515-281-8694
Kansas - Department of Public Health Protection, Bureau of Environmental Remediation	785-296-1503
Missouri - Department of Natural Resources	573-634-2436
Nebraska - Department of Environmental Quality	402-471-2186

National Pesticide Safety Team Network (Chemtrec)

1-800-424-9300

The National Agricultural Chemicals Association has a telephone network. This network can tell the applicator the correct contamination procedures to use to send a local safety team to clean up the spill. An applicator can call the network toll-free at any time.

National Pesticide Information Center

1-800-858-PEST

Call the NPIC network toll-free.

U.S. Environmental Protection Agency (EPA)

913-281-0991

All major pesticide spills must by law be reported immediately to the U.S. Environmental Protection Agency, Region VII Office, 901 N. 5th Street, Kansas City, KS 66101. The following information should be reported:

1. Name, address, and telephone number of person reporting
2. Exact location of spill
3. Name of company involved and location
4. Specific pesticide spilled
5. Estimated quantity of pesticide spilled
6. Source of spill
7. Cause of spill
8. Name of body of water involved, or nearest body of water to the spill area
9. Action taken for containment and cleanup