IPM For Pennsylvania Schools and Childcares

A HOW-TO MANUAL

PennState Extension

IPM For Pennsylvania Schools and Childcares

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Developed by the Pennsylvania Integrated Pest Management Program

The PA IPM Program
is a collaboration between the
Pennsylvania Department of Agriculture and
The Pennsylvania State University
aimed at promoting
integrated pest management
in both agricultural and nonagricultural settings.

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As part of the PA IPM Program,
the Pennsylvania Department of Agriculture,
the Pennsylvania Department of Education,
the Pennsylvania Department of Health, and
The Pennsylvania State University
Colleges of Agricultural Sciences and Education
signed a memorandum of understanding to promote
IPM implementation in schools.
PA IPM drew on this partnership to develop
this manual.

Introduction to the 2019 Edition

The first edition of this manual was published in 2002. Shortly thereafter legislation was enacted requiring each Pennsylvania school district, intermediate unit, and area vocational-technical school to develop an integrated pest management (IPM) plan (Act 35 of 2002), notify parents and guardians 72 hours prior to any pesticide applications, and post warning signs 72 hours prior to and 48 hours after any pesticide applications in school buildings or on school grounds (Act 36 of 2002).

In 2012, the Pennsylvania Department of Agriculture (PDA) Health and Safety Division determined that these regulations apply to childcares as well as K–12 schools since childcare facilities are explicitly covered by the Pennsylvania Pesticide Control Act of 1973. Note that this includes the provision that **only** a licensed pest control operator can apply a pesticide in a facility or a home-based childcare center.

In addition, the Pennsylvania Department of Health recommends that IPM be a part of indoor air quality guidelines for Pennsylvania schools. The U.S. Environmental Protection Agency (EPA) studies of human exposure to air pollutants indicate that indoor levels of pollutants may be two to five times higher than outdoor levels. Children may be especially susceptible to air pollution since they breathe a greater volume of air relative to their body weight than adults. One specific contaminant addressed by the EPA's report *Indoor Air Quality Tools for Schools* are pesticides. Chronic exposure to some pesticides can result in damage to the liver, kidneys, and nervous system.

The following are some of the important changes to this edition:

- Childcare providers have been included due to changes in state regulations.
- A new section addressing the role of pests as asthma triggers can be found in "Asthma, Pests, and Pesticides."
- A new section on "IPM for Bed Bugs" addresses a critical need for evidence-based information about the control of bed bugs in schools and childcares.
- A new section on "Who Does What?" explains what the legislation requires of the school/childcare and others.
- A new section on "Beneficial Insects and Pollinators" has been added that explains the importance of "good bugs" and the need for conservation and provides tips for attracting beneficial organisms to school and childcare gardens and grounds.
- The addition of "How to Develop an IPM Policy and Plan for Your School District or Childcare Facility/Provider" on page 15 shows the parts of an acceptable plan with an outline to adapt it for your school/childcare.
- The Pennsylvania School Boards Association policy has been replaced with an updated version reflecting the effects of the school IPM legislation.
- A sample notification letter for parents and guardians has been added, as well as a sample pest control information sheet used to inform staff and parents and guardians about pesticide applications.
- The "Intent to Apply Pesticides" page has been replaced with a "Notice of Pesticide Application" sign that is 8½ inches by 11 inches as required by the legislation.
- The "Contract Guide Specifications" on page 19 have been somewhat simplified.
- A "Frequently Asked Questions" section has been added on page 163 that answers many of the questions PA IPM has received about proper application of IPM procedures and interpretations of state pesticide laws.
- A description of the Worker Protection Standard is now included in Appendix B on page 182.
- There is now a universal poison control number used nationwide: 1-800-222-1222.
- Copies of the acts are included on pages 178–181.
- Additional resources have been listed and website addresses have been updated.
- At the time of print, several new pests were emerging in Pennsylvania (e.g., spotted lanternfly, emerald ash borer, tick species/diseases vectored, mosquito species/diseases vectored, nonnative and invasive plants and fish) as a result of human behaviors and climate change. Best management practices for these pests is ongoing and evolving as

more is learned from evidence-based research. Please contact your county extension office and visit fact-based websites (those that end in .edu or .gov) for current best management practices.

- The bulk of this manual addresses insect, rodent, and weed pests in detail. For other pests such as plant disease, mold in buildings, etc., visit **extension.psu.edu**.

- Beginning in 2002, Pennsylvania law required that IPM be part of the school curriculum. It is one of nine components of the Academic Standards for Environment and Ecology (E&E). This means that all public and charter schools in Pennsylvania must teach IPM concepts to students in grades K–12. This provides a unique opportunity for interdisciplinary education, collaborations with the facility's team and outside partners. The E&E standards can be viewed at **www.pdesas.org/Standard**.

This edition reflects the changes in Pennsylvania legislation, and it is hoped the manual will enable schools and childcares to enhance their IPM programs and train their personnel to become familiar with IPM practices. Some personnel may wish to be trained as certified pesticide applicators, and we hope this manual will serve as guidance for them. Remember, IPM is not another thing to do, but another way to do things. IPM in itself is not a goal to be reached, but a way to achieve a goal—safer and more effective pest management.

Recommendations given in this manual are current as of 2019. For further information concerning IPM, visit the Penn State Extension Pest Management and Education website at **extension.psu.edu/insects-pests-and-diseases/pest-management-and-education**.

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Contents

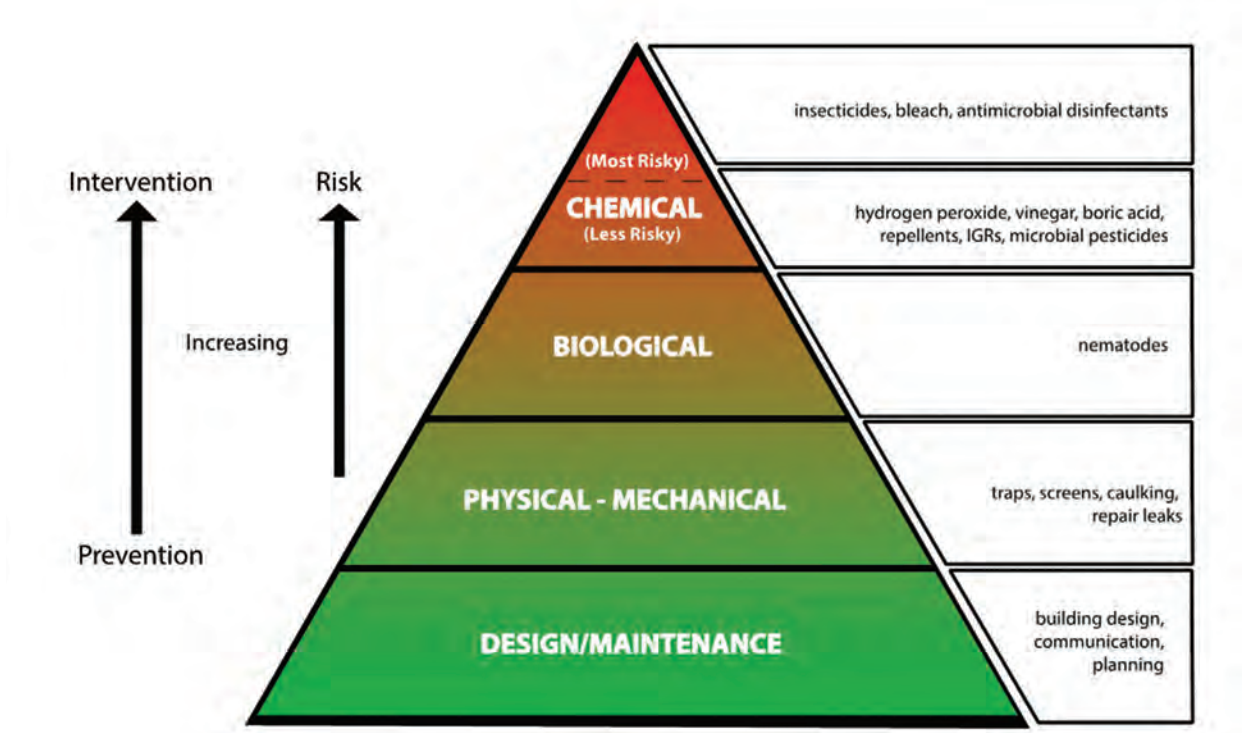
Getting Started with IPM for Schools and Childcares

In 2002, Pennsylvania enacted legislation mandating the adoption of an integrated pest management (IPM) plan for each school district, intermediate unit, and area vocational-technical school in the state, and a 72-hour notification and posting period prior to pesticide use in schools or on school grounds.

In 2012, the Pennsylvania Department of Agriculture's Health and Safety Division determined that these regulations apply to childcare centers as well as K–12 schools since childcare facilities are explicitly covered by the Pennsylvania Pesticide Control Act of 1973. Note that this includes the provision that **only** a licensed pest control operator can apply a pesticide in a facility or a home-based childcare center.

IPM is a decision-making process emphasizing practices that quite often lead to a decrease in the amount of pesticide used. It manages pests through sanitation, exclusion, and nonchemical devices rather than depending exclusively on pesticides. IPM uses information about pests' life cycles to manage them with the least impact on people and the environment.

Pests are any living organisms that negatively affect humans or their property. Pests include weeds and plant diseases, as well as insects that feed on plants or stored products, transmit pathogens, or are nuisances. Other animals, such as snails, ticks, mites, mice, rats, groundhogs, pigeons, and deer, can become pests in certain situations.



Pyramid of IPM Tactics Inside Buildings

IPM Begins with Prevention

An essential element of IPM is to identify the root cause of pest problems at a particular site. Understanding what pests need in order to survive is the key. Pests live in areas that provide basic needs such as food, water, and shelter, so they can often be managed by removing one or more of these necessities, such as food and water sources, or by closing off entry points into buildings.

Proper design of new construction and prompt repairs and building maintenance are essential.

Another essential element of IPM is monitoring on an ongoing basis to determine pest severity.

The judicious use of carefully selected pesticides, resulting in low exposure of students and other nontarget organisms, is a part of an IPM program when monitoring indicates they are needed and necessary.

A fourth essential element of IPM is the involvement of the entire school and childcare community. In addition, some staff should be trained in IPM implementation procedures.

Whether an IPM program raises or lowers costs depends on housekeeping, maintenance, and pest management policies. The costs of setting up an IPM program can also depend on whether pest management services are contracted out or provided by in-house staff. **Pennsylvania law allows pesticide applications in schools and childcares only by certified applicators, registered technicians, or noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must be posted in an area of common access for applications made at or in a school building at least 72 hours prior to and for 48 hours after the application. For applications made on school grounds, the sign must be posted at the place to be treated at least 72 hours prior to and for 48 hours after the application. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied in a school building or on school grounds where students are expected to be present for normal academic instruction or extracurricular activities.** Pesticides must be used in accordance with their EPA-approved label directions, including that it is labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and Safety Data Sheets (SDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label.

If a school or childcare facility performs its own pest control that involves an employee applying a pesticide to the school's or childcare's property, except for the use of disinfectants and sanitizers, there are additional licensing and certification requirements that must be met. These requirements come under the purview of the Pennsylvania Department of Agriculture (PDA) and require the school or childcare to maintain a business license through PDA, retain required insurance, and have at least one individual that is employed by the school or childcare facility to be certified in Category 23—Park or School Pest Control or the specific category(ies) appropriate to the site(s) on which the pesticide(s) are being applied (7 Pa. Code §128.31 and §128.41 [a][3][vii]). In addition to the IPM requirements, when a school or childcare facility uses a pesticide it must also comply with the Pesticide Control Act of 1973 (7 Pa. Code §128), which is also administered by PDA. Should you have any questions regarding the requirements for using pesticides in a school or childcare facility, or the pesticide licensing and certification requirements, contact the PDA Bureau of Plant Industries.

Implementing an IPM program may cost more at first because measures for prevention and facilities maintenance may need to be instituted. However, after the prevention activities have been completed, IPM costs should be lowered due to reduced access by pests. New building design should take pest management factors into consideration. Guidelines for construction details are available in *Pest Prevention by Design,* the report of a national working group. See the "References and Resources" section in this manual for more information.

The EPA's "Managing Pests in Schools" website at **www.epa.gov/managing-pests-schools** contains many resources, including a large library of webinars on many topics (see **www.epa.gov/managing-pests-schools/webinars-about-integrated-pest-management-schools**), and is recommended for staff training.

Steps for Starting an IPM Program

Schools and childcare providers should take the following steps to start an IPM program.

1. Develop an IPM Policy Statement

The policy statement should explain what is expected, how existing services will be included, and how students and staff can take part in the program. A model policy statement (Policy 716—Integrated Pest Management in Schools) developed by the Pennsylvania Integrated Pest Management (PA IPM) Program and the Pennsylvania School Boards Association is found on pages 13–14. This may be modified as necessary.

2. Set Pest Management Objectives

Examples of pest management objectives include:

- Designing new facilities and structures to prevent pest occurrence and damage
- Managing pests that may interfere with learning in a facility
- Eliminating the possibility of injury to students and staff
- Preserving the integrity of buildings
- Maintaining sports fields
- Responding to children's health issues and preventing the spread of disease
- Communicating about the IPM program with administrators, teachers, parents, students, and maintenance personnel

3. Designate Pest Management Roles

Designating roles for pest management professionals, staff, students, and parents is an important part of an IPM program. Cooperation is critical. The more students and staff join in, the better an IPM program will work.

- **IPM coordinator.** Each district or other entity should designate one individual as the district coordinator for the IPM program. In districts with more than one building, each building should designate a person to interact with the district IPM coordinator.
- **IPM advisory committee.** Some schools and childcare providers have found it helpful to establish an advisory committee to facilitate communication. It could include parents, teachers, kitchen and maintenance personnel, and other interested individuals.
- **Students and staff.** The most important job for students and staff is to help keep the facility clean. Preventing pests depends on everyone working together to clean up litter and leftover food. Including students at multiple grade levels is also beneficial. Allowing students to be involved in an advisory capacity encourages ownership and awareness.
- **Parents/guardians.** Parents' and guardians' first school pest management responsibility is to learn about and follow IPM practices at home. Pests carried from home to school in notebooks, lunchboxes, or clothing can slow the success of an IPM program.
- **Pest manager or contractor.** The pest manager (in-house personnel certified as a pesticide applicator in Category 23 of 7 Pa. Code §128.42) or contractor (certified pesticide applicator hired from outside the system) is the person who inspects the facility, monitors for pests, and decides if prevention or suppression measures are necessary. The pest manager also keeps records of any pesticide use, including the names of pesticides applied, EPA registration number, amount, location, and dates of application.

4. Set Action Thresholds

The mere presence of a pest does not always require the application of a pesticide. The pest manager and school staff should decide in advance how many individuals of a particular species are harmless and how many require management (in other words, how many can be tolerated). This is called the "action threshold" for management of a particular pest. In some cases, the action threshold may be reached with the detection of a solitary pest that may pose a significant public health concern. In other instances, the pest may simply be a nuisance and will require a larger population before management steps are needed. The magnitude of the response should be scaled to the size and concern (health or nuisance) of the problem. For example, one cockroach will entail a different response from what 100 or 1,000 cockroaches would require. This is also called "assessment-based pest management."

5. Inspect Sites and Monitor for Pests

Inspecting sites for pests or conditions that are conducive to pests is an important part of IPM. The pest manager should identify any pests found and attempt to determine where they came from. Simple structural and maintenance changes to the building may be required and used to reduce pest numbers.

Monitoring traps should be placed in areas where pests have been reported. Count the number of pests caught to determine if action thresholds (the number of pests that can be tolerated) have been reached and suppression measures are necessary.

6. Apply IPM Management Strategies

When the number of pests exceeds the preset action threshold, the pest manager takes action. The pest manager may physically remove the pests or suggest habitat modifications that would prevent pests from finding food, shelter, and water. Other management strategies used in an IPM program may include building repair, improved sanitation, or a targeted application of an appropriate pesticide.

7. Evaluate Results and Keep Records

Accurate recordkeeping allows the pest manager to evaluate the success of the IPM program. Records also help forecast when a seasonal pest may appear or an outbreak may occur.

After a period of time, people involved with the program will gain a sense of IPM activity priorities. For example, any garbage or trash that may attract pests in and around the building must be removed daily.

IPM Recordkeeping Activities

Keep **pest sighting logs** (template on page 29) in each room and check them on a weekly basis. Depending on circumstances, sticky traps or glue boards used for monitoring cockroaches and other crawling insects should be checked as needed.

Regular (monthly) flashlight inspections of kitchen areas, behind appliances, sinks, soda machines, storage facilities, and other areas may be needed to locate cockroaches, silverfish, and ants. The cafeteria inspection checklist on pages 30–31 can be used for these inspections.

Routine inspections of athletic fields, turf, and ornamental plants should occur on a weekly (especially on heavily used athletic fields) or at least a biweekly schedule during the growing season.

Seasonal inspections may be helpful in preventing some problems. In the fall, as the weather starts to turn cooler and just as the school year is starting, many outside pests begin to migrate indoors in search of shelter. Be alert and prevent their entry into buildings. In spring, birds may attempt to nest in building corners or openings, increasing the possibility of parasitic bird mites entering buildings.

Needed structural repairs should be made as soon as feasible to minimize pest entry. Check for gaps around doors and pipes, wires in walls, torn screens, cracks in walls, and other flaws that could give pests access.

Consider creating a student "Pest Patrol" club to monitor various areas of the building and grounds for pests. Many eyes will spot potential pest problems more efficiently than one person can. For ideas, see **www.epa.gov/safepestcontrol/join-our-pest-patrol-backyard-activity-book-kids-integrated-pest-management**.

The IPM coordinator, teachers, students, parents, and administrators need to **communicate regularly** about perceived problems.

Elements of a School and Childcare IPM Policy

The PA IPM Program has prepared this manual to help your school or childcare facility establish an IPM plan and come into compliance with the 2002 school and childcare IPM legislation. This section has several documents (listed below) that should help you develop an IPM plan.

- **School IPM Legislation—Acts 35 and 36: Who Does What?** (pages 10–11). This section explains what the legislation requires of the school or childcare facility, the pest management professional, and the Pennsylvania Department of Agriculture.

- **Policy Statement—IPM Policy for Pennsylvania Schools and Childcare Providers** (pages 13–14). The first step in an IPM program is to establish an organizational policy. The next is to inform teachers, staff, parents, and students about the policy. The notice can be printed and posted on bulletin boards to inform everyone.
- **IPM Plan—How to Develop an IPM Policy and Plan for Your School District or Childcare Facility/Provider** (pages 15–18). This is an annotated list of the parts that can be included in an IPM plan, along with a sample plan your organization can modify to fit your situation.
- **Contracts—Contract Guide Specifications or Request for Proposal for IPM Programs in Pennsylvania Schools and Childcares** (pages 19–23). School and childcare officials may find these guidelines useful when creating bid specifications for pest management proposals. These specifications are provided as a starting place for those facilities that outsource pest management. If used as a template for contracts, these guidelines should provide the pest manager with the necessary descriptions and details in order to deliver quality IPM for schools and childcare facilities.
- **Forms:**
  - **Sample Notification Letter for Parents or Guardians** (in English on page 25; in Spanish on page 26). This sample letter can be modified for the school to use in generating a list of parents and guardians who want notification of each pesticide application. It should be sent out at the beginning of each school year.
  - **Sample Pest Control Information Sheet** (page 27). This sheet can be used to notify staff and parents and guardians about pesticide applications.
  - **Sample Notice of Pesticide Application** (page 28). The posting required by the legislation must be at least 8½ by 11 inches and in place 72 hours prior to and for 48 hours after any pesticide applications.
  - **IPM Pest Sighting Log** (page 29). A pest sighting log should be kept at each facility, building, floor, or room—whichever is most practical with your specific IPM plan. An individual (the district-wide IPM coordinator or building coordinator) should be identified to monitor this document. All employees in the given area should know who this person is and report any pest sightings accordingly. The pest manager reviews this document at the beginning of each visit and responds appropriately. Any treatments that are conducted should be recorded on this document by the pest manager. Review of this form should be included as part of the pest control operator's periodic inspection process.
  - **IPM Cafeteria Inspection Checklist** (pages 30–31). Because food handling areas tend to be the source of many pest infestations, a separate inspection form is provided for cafeterias. The pest manager can use this document to ensure a thorough inspection is completed. One of these checklists should be completed during each inspection. The pest manager should not limit the inspection solely to what is indicated on the checklist. The IPM coordinator should review the pest manager's comments on the checklist and take appropriate action.

School IPM Legislation

Acts 35 and 36: Who Does What?

In April 2002, the governor of Pennsylvania signed two bills that mandate the adoption of an IPM plan for each school district, intermediate unit, and area vocational-technical school in the state, and a 72-hour notification and posting period prior to pesticide use in schools or on school grounds. In 2012, it was determined that childcare facilities, covered by the Pesticide Control Act of 1973, were also subject to these regulations. Charter schools are supported by the school district, so they are also subject to these regulations. Private and parochial schools are not, but we would encourage voluntary compliance in the interest of child health and adoption of best management practices.

IPM is an approach to managing pests that minimizes human health effects and environmental contamination. IPM is a decision-making process that manages pests through a combination of sanitation, exclusion, and nonchemical

tactics rather than depending exclusively on pesticides. Over time, the efficiencies in an IPM program can save schools and childcares money and reduce the exposure of children to both pests and pesticides.

Act 35 amends the Public School Code of 1949 by adding section 772.1—Integrated Pest Management Programs. This act required the school districts of Pennsylvania to adopt an IPM plan by January 1, 2003, and charges PDA with the following:

- Maintain a Hypersensitivity Registry (this is a current practice). Information about the Hypersensitivity Registry can be found in the "Additional Resources" section at the end of this manual.
- Designate an IPM coordinator.
- Prepare a standard structural IPM agreement (see "Contract Guide Specifications" on pages 19–23).
- Provide other materials and assistance to help schools develop an IPM plan. (This manual can be purchased from Penn State Extension at **extension.psu.edu** or by calling 1-877-345-0691.)
- Promulgate regulations. (The Pesticide Control Act of 1973 gives rules and regulations concerning pesticide use in Pennsylvania.)

Act 36 amends the code by adding to the same section 772.1—Notification of Pesticide Treatments at Schools. This act provides the pesticide applicators and the school with specific responsibilities.

Prior to any pesticide application either in a school building or on school grounds, it is the responsibility of the pesticide applicator to supply to the chief school administrator or building manager with the following:

- A pest control information sheet with the date of treatment; name, address and phone number of the applicator; and the pesticide used (see sample on page 27)
- A pest control sign that is at least 8½ inches by 11 inches in size (see sample on page 28)

The school district's responsibilities are as follows:

- Post the pest control sign in an area of common access where individuals are likely to view the sign at least three days before and two days after each planned treatment.
- Provide a copy of the pest control information sheet (by hard copy or email) to every individual working in the school building at least three days before treatment.
- Provide notice (the pest control information sheet is sufficient) to the parents or guardians of students enrolled in the school at least three days before each planned treatment. The notice is to be provided to all parents or guardians using normal school communications or to a list of interested parents or guardians who, at the beginning of each school year or upon the child's enrollment, requested notification of individual applications of pesticides.
- Prohibit applications of pesticides within a school or childcare building or on school grounds where students are expected to be present within seven hours following the application, except where pests pose an immediate threat to the health and safety of students or employees. In this case, the facility may authorize an emergency pesticide application and then notify by telephone any parent or guardian who has requested such notification.
- Maintain detailed records of all chemical pest control treatments for at least three years. These can be provided by the pesticide applicator if included in the request for proposal.

Exemptions: None of the above applies to the application of disinfectant and antimicrobial products; self-containerized baits in areas not accessible to students; gel-type baits placed in cracks, crevices, or voids; or swimming pool maintenance chemicals. Other state laws do, however, require recordkeeping of the baits and swimming pool maintenance chemicals (but not the disinfectant and antimicrobial products), so pesticide application records are required for these treatments and they are to be maintained for at least three years.

A list of frequently asked questions concerning the acts is provided at the end of this manual (page 163).

The Pennsylvania IPM Program can help you establish your IPM plan. If you need further assistance, please contact us at the Pennsylvania Department of Agriculture at 717-787-4843 or at Penn State at 814-865-1895.

Model IPM Policy for Schools and Childcare Providers

Policy 716: IPM in Schools and Childcares

The perceived impact on children of pesticide use on school and childcare grounds has stimulated interest in IPM. As part of this public discussion, the implementation of IPM has been forwarded by citizens' groups and government alike as a means of reducing many of the concerns associated with pesticides. The PA IPM Program has responded to this phenomenon in several ways.

PA IPM is a collaboration between Penn State's College of Agricultural Sciences and the Pennsylvania Department of Agriculture. All PA IPM activities and responsibilities are a product of this collaboration. The school's IPM program has two main thrusts. The first is to facilitate the implementation of IPM strategies to manage pests in school and childcare facilities and grounds. The second is to move IPM principles and activities into the K–12 curriculum as an example of interdisciplinary, environment-oriented problem solving. IPM is included in the academic standards for Environment and Ecology (Public School Code of 1949 [24 P. S. §§ 1-101—27-2702] [22 Pa. Code Ch. 4. Academic Standards and Assessment]). You can view the standards online at **www.pdesas.org/standard**. In addition, the Department of Education, the Department of Health, and Penn State's College of Education have joined the Department of Agriculture and Penn State's College of Agricultural Sciences in a Memorandum of Understanding (signed March 2000) to promote IPM in schools.

A committee of staff members from the Pennsylvania School Boards Association and the PA IPM Program collaborated to draft materials to assist school boards and administrators in implementing IPM.

In addition to adopting an IPM policy, a school or childcare board should consider the following:

1. Designate a school district employee to be IPM coordinator.
2. Form a stakeholder advisory group that may consist of parents, students, teachers, school maintenance personnel, school administrators, pest management professionals, air quality experts, etc.
3. Write an IPM policy pursuant to local needs and conditions.

The following model policy and implementation procedures are provided for your information and assistance in preparing and executing a school district or childcare organization IPM policy. Each school district or childcare organization should determine the policy and procedures most appropriate for its needs, in consultation with the district's or organization's solicitor.

IPM Policy for Pennsylvania Schools and Childcare Providers

Developed by the PA IPM Program and the Pennsylvania School Boards Association

Section: Property
Title: Integrated Pest Management
Adopted: _____
Revised: _____

716. Integrated Pest Management	
1. Purpose	The school district/childcare organization shall utilize integrated pest management (IPM) procedures to manage structural and landscape pests and use toxic chemicals to alleviate pest problems with the least possible hazard to people, property, and the environment.
Title 22 Sec. 4.12 Pol. 102	The organization shall integrate IPM education into the curriculum in accordance with relevant academic standards.
2. Definition	IPM is the coordinated use of pest and environmental information to design and implement pest control methods that are economically, environmentally, and socially sound. IPM promotes prevention over remediation, and it advocates the integration of at least two or more strategies to achieve long-term solutions.
SC772.1	An IPM plan establishes a sustainable approach to managing pests by combining biological, design/maintenance/cultural, physical/mechanical, and chemical tools in a way that minimizes economic, health, and environmental risks.
3. Authority 3 PA C.S.A. Sec. 111.21–111.61 7 Pa. Code Sec. 128 et seq.	The Board establishes that the school district shall use pesticides only after consideration of the full range of alternatives, based on analysis of environmental effects, safety, effectiveness, and costs.
SC772.1	The Board shall adopt an IPM plan for buildings and grounds that complies with policies and regulations promulgated by the Department of Agriculture.
4. Delegation of Responsibility	{ } The Superintendent or designee shall be responsible to implement IPM procedures and coordinate communications between the district and the approved contractor. { } The Board shall designate an employee to serve as IPM coordinator for the organization.
SC772.1	{ } The Superintendent or designee shall be responsible to annually notify parents and guardians of the procedures for requesting notification of planned and emergency applications of pesticides in organization buildings and on grounds. { } Appropriate personnel involved in making decisions relative to pest management shall participate in update training.

5. Guidelines	Pest management strategies may include education, exclusion, sanitation, maintenance, biological and mechanical controls, and site-appropriate pesticides. An IPM decision shall consist of the following five steps: 1. Identify pest species. 2. Estimate pest populations and compare to established action thresholds. 3. Select the appropriate management tactics based on current onsite information. 4. Assess effectiveness of pest management. 5. Keep appropriate records. { } An IPM program shall include the education of staff, students, and the public about IPM policies and procedures.
SC772.1	When pesticide applications are scheduled in school or childcare buildings and on grounds, the organization shall provide notification at least 72 hours before the planned application in accordance with the law, including: 1. Posting a pest control sign in an appropriate area for the required time intervals. 2. Providing the pest control information sheet to all individuals working in the facility. 3. Providing required notice to all parents and guardians of students or to a list of parents and guardians who have requested notification of individual applications of pesticides.
SC772.1	Where pests pose an immediate threat to the health and safety of students or employees, the organization may authorize an emergency pesticide application and shall notify by telephone any parent and guardian who has requested such notification.
SC772.1 Title 22 Sec. 4.12 School Code 772.1 7 Pa. Code Sec.128 et seq. 3 PA C.S.A. Sec. 111.21–111.61 7 U.S.C. Sec. 136 et seq. Board Policy 102	The organization shall maintain detailed records of all chemical pest control treatments for at least three years. Information regarding pest management activities shall be available to the public at the organization's administrative office.

How to Develop an IPM Policy and Plan for Your School District or Childcare Facility/Provider (Complying with Pennsylvania Act 35 of 2002)

Act 35 required all school districts, intermediate units, and vocational-technical schools in Pennsylvania to adopt an IPM plan by January 1, 2003. Childcares were required to adopt an IPM plan in 2012, in accordance with the law. The PA IPM Program—a collaboration of the Pennsylvania Department of Agriculture and Penn State to promote IPM in agriculture, urban, and other settings—is providing this guide to aid schools and childcare providers in developing their IPM plan.

An IPM **policy** is a generalized guide to help school and childcare personnel develop a more detailed plan for action. An IPM **plan** contains the more specific instructions about how to implement the policy at various types of facilities.

The PA IPM Program, in conjunction with the Pennsylvania School Boards Association, developed the IPM policy for schools (modified to include childcare providers in June 2017) located just before this section. The IPM policy should be written before the IPM plan and included as a part of it.

The IPM plan is basically a blueprint of how your organization will manage pests through prevention, monitoring, and safe control methods. On paper, your school or childcare IPM plan states what your school or childcare is trying to accomplish regarding pests and the use of pesticides. It needs to reflect your facility's site-specific needs. Your plan will differ from those of other schools or childcares. Finally, your plan will be a working document and should be reviewed at least annually and updated as appropriate.

Your IPM plan should include the following components:

1. General facility information
2. Name and title of your organization's IPM coordinator
3. Names and titles of individuals on your organization's IPM committee
4. School/childcare IPM policy
5. Identification and description of your specific pest problem(s)
6. Description of your organization's IPM information flow (communication strategy) and training format
7. Record of pesticide(s) applied on school or childcare property
8. Record of nonpesticide actions taken on school or childcare property
9. Evaluation of your organization's IPM program
10. Description of the location of your organization's IPM plan and records

The format of your plan can be as follows:

1. **General facility information.** Provide the facility name, address, city, zip code, telephone number, and email address; who the plan was prepared by; and the date the plan was prepared/updated.
2. **Name and title of your organization's IPM coordinator.** The IPM coordinator is the individual within the organization who is generally in charge of pest control activities for the school or childcare. This individual is someone who has the authority and backing of the administration or management, has the primary responsibility for ensuring the IPM plan is carried out, and is the primary contact for the IPM committee. Ultimately, this person is tied directly to the integration of all IPM activities through the coordination of all parties, including custodial, building, food service, outside vendors, the pest control contractor, grounds staff, students, parents, and teachers. The organization may designate their facility director or head custodian as the IPM coordinator. The pest control contractor **cannot** be the IPM coordinator; the IPM coordinator should be someone directly employed by the school.
3. **Names and titles of individuals on your organization's IPM committee.** The IPM committee consists of individuals who have interests/concerns or who are involved in activities directly or significantly related to pest control at the facility. They might include the school nurse, a representative of the food service staff, a teacher representative, a custodian, the pest control contractor, a PTA member, etc. Outdoor plans might also include a representative of the school athletic department,

a parks superintendent, or others who use the playing fields.

4. **School/childcare IPM policy.** The statement of purpose should state the intent of the school administrator or management to implement an IPM program for your organization. It should provide brief guidance on what specifically is expected—incorporation of existing services into an IPM program, and the education and involvement of students, staff, and pest control contractor.

5. **Identification and description of your specific pest problem(s).** Proper identification and inventory of your pest problems is critical to understanding their management and prioritizing and selecting the appropriate nonpesticide and pesticide treatment options. What are the most common pest problems? Are they new or continuing problems? What specific areas are being affected? What time of year do pest problems occur? Are problems related to specific structural deficiencies or sanitation issues?

6. **Description of your organization's IPM information flow (communication strategy) and training format.** Describe how pest problems specific to your facility will be reported. Indicate the method that will be used and specify the location of a pest and/or service log. Indicate who in the facility will be responsible for responding to sanitation and building repair problems that are identified through inspection reports. For example, if a kitchen staff member observes roaches in the cafeteria, who should the employee inform so corrective action can be taken?

   Training is another essential element of the IPM plan. Identify the individual(s) providing the training. Who will receive the training? For example, if the maintenance personnel do not recognize that nonchemical sticky traps are used as monitoring devices, these important tools may be inadvertently discarded. Also, sanitation should not be viewed as only the maintenance crew's responsibility. If students and staff are shown the connection between food, water, clutter, and pests, they are more likely to take sanitation seriously.

7. **Record of pesticide(s) applied on school or childcare property.** Pesticides should not be used unless the pest has been identified and its presence verified. Pesticides may be used only by a licensed or certified pesticide applicator (never by a teacher or an unlicensed individual). Pesticides are generally used when other control methods are not effective or practical for resolving a pest problem. Pesticides must be used in accordance with their EPA-approved label directions, including that it is labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and Safety Data Sheets (SDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label. Be aware that Act 36, the companion school legislation, under **Pennsylvania law allows pesticide applications in schools and childcares only by certified applicators, registered technicians, or noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must be posted in an area of common access for applications made at or in a school building at least 72 hours prior to and for 48 hours after the application. For applications made on school grounds, the sign must be posted at the place to be treated at least 72 hours prior to and for 48 hours after the application. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied in a school building or on school grounds where students are expected to be present for normal academic instruction or extracurricular activities.**

8. **Record of nonpesticide actions taken on school or childcare property.** The IPM plan should include nonpesticide pest management methods and practices such as sanitation/housekeeping, trapping, pest proofing (caulking, sealing cracks, repairing screens), and light management.

9. **Evaluation of your organization's IPM program.** The IPM plan should be evaluated at least annually. Is the IPM plan working? What changes are necessary? Has new technology replaced some of the former pest control tactics?

10. **Description of the location of your organization's IPM plan and records.** Records of pesticide use, service reports, logbook, posting and notification, and emergency waivers should be kept at a central location readily available when needed. Remember, records of pesticide use must be retained for three years in Pennsylvania.

Sample IPM Plan

Only include information that is specific and relevant to your school or childcare facility.

1. General facility information:

School Name:	ABC School
Address:	123 Center Street
City, Zip Code:	Average, PA 12345-6789
Telephone Number:	123-456-7890
Email Address:	abc.sch@school
Plan Prepared By:	John C. Ustodian, Facilities Manager
Date Prepared:	March 1, 2018

2. Name and title of your organization's IPM coordinator:

Name:	John C. Ustodian
Title:	Facilities Manager
Telephone Number:	098-765-4321
Email Address:	jcust.abc@school

3. Names and titles of individuals on your organization's IPM committee:

Name:	John C. Ustodian
Title:	Facilities Manager
Name:	Bea Stinger
Title:	Teacher Representative
Name:	Pyccop Andropov
Title:	PTA Member and Parent
Name:	
Title:	

4. School/childcare IPM policy:

5. Identification and description of your specific pest problem(s):

The ABC Middle School has historically had problems with ants and mice. Our pest management contractor has identified these pests as pavement ants and house mice. The mice are usually noticed in the fall as the weather cools off, while the ants are seen throughout the school year. There has been a problem with staff and students leaving food wrappers and crumbs in various locations. Current control efforts have been reactive and not effective. The school plans to set up a monitoring program using glue boards for the mice and sticky traps for the ants to detect and pinpoint infestations or hot spots. Maintenance personnel and staff and students will be instructed concerning food waste sanitation. Pest reporting sheets will be provided to each classroom and the kitchen area and will be checked on a regular basis by John C. Ustodian (IPM coordinator).

6. Description of your organization's IPM information flow (communication strategy) and training format:

John C. Ustodian (IPM coordinator) will meet monthly with Ima Beatle (pest management contractor) to cover monitoring reports. An initial meeting will be held on January 23 to establish a pest activity log binder. The log binder will be kept in the main office of administration and pest activity sheets will be distributed to teachers and staff. The sheet will indicate identification of pest(s) (if known), number seen, date, time, and location. The assistant principal, Ura Friend, will be responsible for notifying John C. Ustodian of logged pests from staff. Ima Beatle (pest management contractor) will respond to log complaints. If any sanitation or structural changes are needed, it will be written in the log along with remedial recommendations. Specific service reports will also be placed in the log binder that documents particular actions taken by the pest management contractor.

Staff, teachers, and students will be instructed on how to log pest complaints and be given a brief overview on pest identification and the conditions that promote the pests. Pamphlets and fact sheets will be made available at the time of training and/or posted on bulletin boards in specific areas, such as the cafeteria and teachers' lounge. This information will focus on pest reduction strategies connecting people's behavior—such as overwatering plants, eating at desks, leaving crumbs on the floor, etc.—to pest problems.

More specific training will be held annually and separately for maintenance and kitchen staff.

7. Record of pesticide(s) applied on school or childcare property:

Ima Beatle is our licensed pesticide contractor (BU-00000). Indoors, _____,

a bait box, will be used to control the ants. For emergency situations, _____

will be used to control flying stinging insects such as wasps.

8. Record of nonpesticide actions taken on school or childcare property:

Whenever practical, nonpesticide means to manage or limit pests will be used. Ima Beatle (pest management contractor) will perform a thorough inspection and provide the IPM committee with a report identifying conditions that are contributing to our ant and mouse problems. Sanitary/housekeeping deficiencies will be reported as well. Once this is done, a priority list will be generated to optimize a plan of corrective actions such as sealing openings with caulk and copper mesh, repairing leaks and screens, reducing clutter, and organizing stored goods so they are kept off the floor and away from walls. Mechanical traps will be used to reduce pests.

9. Evaluation of your organization's IPM program:

At least once a year, the IPM committee will meet with the pest control contractor to evaluate the success or failure of this IPM plan.

10. Description of the location of your organization's IPM plan and records:

A copy of this plan, annual evaluations, pest control contractor recommendations, and pesticide use records will be kept on file in the main office.

For additional information, search for "School IPM" on the Penn State Extension website at **extension.psu.edu**, contact PDA at 717-772-5204, or see the EPA webpage on adopting IPM at **www.epa.gov/managing-pests-schools**.

Contract Guide Specifications or Request for Proposal for IPM Programs in Pennsylvania Schools and Childcares

Disclaimer: This document is intended for guidance and information only and does not pertain to any actual contract. Contract details need to be adapted to local circumstances. Contact your school or childcare solicitor or attorney for appropriate wording. For additional information, contact the PA IPM Program at 717-772-5204 or 814-865-1895.

1. General

a. Description of Program

This specification is part of a comprehensive integrated pest management (IPM) program for the premises listed herein. The goal of IPM is to achieve long-term, environmentally sound pest suppression through the use of effective management practices. Management strategies in an IPM program begin with prevention, including structural and procedural modifications that reduce the food, water, harborage, and access used by pests, and the judicious use of pesticides when need is indicated by monitoring.

b. Contractor Service Requirements

The contractor shall furnish all supervision, labor, materials, and equipment necessary to accomplish the surveillance, trapping, pesticide application, and pest removal components of the IPM program. The contractor shall also provide detailed, site-specific recommendations for structural and procedural modifications to aid in pest prevention. **Note:** The buildings or partial areas within each building included in this contract are *[list buildings/ partial areas (pool, kitchens, etc.) here]*.

c. Contractor Bidding Requirements

In order for a company to qualify for the bidding process, it must possess a valid commercial pesticide application business license from the Pennsylvania Department of Agriculture and provide three references attesting to the company's knowledge or experience in the field of IPM.

2. Pests Included and Excluded

a. The Contractor Shall Adequately Suppress the Following Pests

Indoor populations of rats, mice, cockroaches, ants (not including carpenter, pharaoh, and odorous house ants), fleas, stinging wasps, spiders, and any other arthropod pests not specifically excluded from the contract. Populations of these pests that are located outside of the specified buildings but within the immediate exterior perimeter of the buildings are also included.

b. Populations of the Following Pests Are Excluded from This Contract and Must Be Separately Negotiated

Note that birds, bats, and the like are monitored under other state agency jurisdiction, such as the Pennsylvania Game Commission, Fish and Boat Commission, and Department of Agriculture, and may require additional permitting, reporting, and so forth for management and/or removal/eradication.

3. Initial Building Inspections

The contractor shall complete a thorough initial inspection of each building or site prior to the starting date of the contract. The purpose of the initial inspection is for the contractor to evaluate the pest management needs of all premises and to identify problem areas and any equipment, structural features, or management practices that are contributing to pest infestations. Access to building space shall be coordinated with the IPM coordinator. The IPM coordinator will inform the contractor of any restrictions or areas requiring special scheduling.

4. Pest Management Plan

The contractor shall submit to the IPM coordinator a pest management plan at least five working days prior to the starting date of the

contract. Upon receipt of the pest management plan, the IPM coordinator will render a decision regarding its acceptability within five working days. If aspects of the pest management plan are incomplete or disapproved, the contractor shall have five working days to submit revisions. The contractor shall be on site to perform the initial service visit for each building within the first 30 working days of the contract. The pest management plan shall consist of five parts as follows:

a. Proposed Materials and Equipment for Service

The contractor shall provide current labels and Safety Data Sheets (SDS) of all pesticides to be used and brand names of pesticide application equipment, rodent bait boxes, insect and rodent trapping devices, pest monitoring devices, pest surveillance and detection equipment, and any other pest management devices or equipment that may be used to provide service.

b. Proposed Methods for Monitoring and Surveillance

The contractor shall describe methods and procedures to be used for identifying sites of pest harborage and access, and make objective assessments of pest population levels throughout the term of the contract.

c. Service Schedule for Each Building or Site

The contractor shall provide complete service schedules that include specific day(s) of the week of contractor visits and the approximate time of each visit.

d. Description of Any Structural or Operational Change That Would Facilitate the Pest Management Effort

The contractor shall describe site-specific solutions for observed sources of pest food, water, harborage, and access.

e. Commercial Pesticide Applicator Certificates or Licenses

The contractor shall provide photocopies of the pest control company's pesticide business license, pesticide applicator certificate, and technician registration for every contractor employee who will be performing on-site service under this contract. The contractor shall be responsible for carrying out work according to the approved pest management plan. The contractor shall receive the concurrence of the IPM coordinator prior to implementing any subsequent changes to the approved pest management plan, including additional or replacement pesticides and on-site service personnel.

5. Recordkeeping

The contractor shall be responsible for maintaining a pest management logbook or file for each building or site specified in this contract. These records shall be kept on site and maintained on each visit by the contractor. Each logbook or file shall contain at least the following items:

a. Pest Management Plan

A copy of the contractor's approved pest management plan, including labels and SDS for all pesticides used in the buildings, brand names of all pest management devices and equipment used in the buildings, a plot plan of rodent management devices with service/install protocols, and the contractor's service schedule for the buildings.

b. Work Request and Inspection Forms

Work request and inspection forms will be used to advise the contractor of routine service requests and to document the performance of all work, including emergency work. Upon completion of a service visit to the building or site, the contractor's employee performing the service shall complete, sign, and date the form, and return it to the logbook or file on the same or succeeding day of the service rendered.

c. Contractor's Service Report Forms

Customer copies of a contractor's service report form documenting all information on pesticide application.

6. Manner and Time to Conduct Service

a. Time Frame of Service Visits

Under the Pennsylvania Department of Agriculture's Title 7—Pesticide Rules and Regulations (§ 128.106; see page 177) a contractor is prohibited from applying a pesticide in a common access area within a building or on school grounds when students are expected to be in that area for normal academic instruction or organized extracurricular activities within seven hours following the application. When it is necessary to perform work outside of the regularly scheduled hours set forth in the pest management plan, the contractor shall notify the IPM coordinator in advance.

b. Safety and Health

The contractor shall observe all safety precautions throughout the performance of this contract. All work shall comply with the **Pennsylvania Pesticide Control Act of 1973 and Title 7—Agriculture, Department of Agriculture, Part V. Bureau Of Plant Industry, Pesticides Rules and Regulations** and municipal safety and health requirements. Where there is a conflict between applicable regulations, the most stringent will apply. The contractor shall assume full responsibility and liability for compliance with all applicable regulations pertaining to the health and safety of personnel and public during the execution of work.

c. Special Entrance

Certain areas within some buildings may require special instructions for persons entering them. Any restrictions associated with these special areas will be explained by the IPM coordinator. The contractor shall adhere to these restrictions and incorporate them into the pest management plan.

d. Uniforms and Protective Clothing

All contractor personnel working in or around buildings designated under this contract shall wear distinctive uniform clothing. The contractor shall determine the need for and provide any personal protective items required for the safe performance of work. Protective clothing, equipment, and devices shall comply with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the specific pesticide labels.

e. Vehicles

Vehicles used by the contractor shall be identified in accordance with Commonwealth of Pennsylvania regulations and display the business license number as required by PDA. All vehicles will be locked when unattended on client property.

7. Special Requests and Emergency Service

On occasion, the IPM coordinator may request that the contractor perform corrective, special, or emergency service(s) that are beyond routine service requests. The contractor shall respond to these exceptional circumstances and complete the necessary work within one working day after receipt of the request. If the emergency service involves wasps or yellowjackets, it should be on a "same-day" response when the call is made. In the event that such services cannot be completed within one working day, the contractor shall immediately notify the IPM coordinator and indicate an anticipated completion date. If pesticides are needed, the contractor will provide a pest control information sheet to the IPM coordinator (see 9e) and a pest control sign (see 9f) to be posted in the area for the next 48 hours.

8. Contractors and Contractor Personnel

All contractors must be licensed as a qualified pest control business with the Pennsylvania Department of Agriculture (PDA). Throughout the term of this contract, all contractor personnel providing on-site pest management services must maintain and possess valid certification in Category 23 (Park or School Pest Control) or the applicator category(ies) specific to the pest(s) being controlled, or registered technician cards issued by PDA. At the discretion of the school district, the contractor personnel may need a criminal background check (Act 34 clearance), child abuse background check (Act 151 clearance), and, if from out of state, an FBI fingerprint card.

9. Use of Pesticides

The contractor shall be responsible for the application of pesticides according to the label. All pesticides used by the contractor must be registered with the U.S. Environmental Protection Agency (EPA) and PDA. Transport, handling, and use of all pesticides shall be in strict accordance with the manufacturer's label instructions and all applicable federal, state, and local laws and regulations. The contractor shall adhere to the following rules for pesticide use:

a. Approved Products

The contractor shall not apply any pesticide product that has not been included in the pest management plan or approved in writing by the IPM coordinator.

b. Pesticide Storage

The contractor shall not store any pesticide product on the premises listed herein.

c. Application by Need

Pesticide application shall be according to need and not by schedule. As a general rule, application of pesticides in any inside or outside area shall not occur unless visual inspections or monitoring devices indicate the presence of pests in that specific area. Preventive pesticide treatments of areas where surveillance indicates a potential insect or rodent infestation are acceptable on a case-by-case basis.

d. Minimizing Risk

When pesticide use is necessary, the contractor shall employ products that pose minimum risk, have the most precise application technique, and need the minimum quantity of pesticide to achieve adequate pest management.

e. Pest Control Information Sheet

This form, containing the date of treatment, the name, address, and phone number of the applicator, and the pesticide name(s) and EPA registration number(s) used, must be provided to the IPM coordinator at least 72 hours prior to any pesticide application for the school district to give the 72-hour notification required by Act 36. The certified applicator will notify any persons on the Pennsylvania Pesticide Hypersensitivity Registry not less than 12 hours and not more than 72 hours prior to the pesticide application.

f. Pest Control Sign

This sign, with the date and locations of application, must be provided to the IPM coordinator at least 72 hours prior to any pesticide application for posting in the appropriate places, and must remain for 48 hours after the application.

10. Insect Management

a. Emphasis on Nonpesticide Methods

The contractor shall use nonpesticide methods of management wherever possible. For example:

- Portable vacuums with HEPA filters rather than pesticide sprays should be strongly considered for initial cleanouts of cockroach infestations, swarming (winged) ants and termites, and management of spiders in webs wherever appropriate.
- Trapping devices, rather than pesticide sprays, shall be used for indoor fly management wherever appropriate.
- Utilization of cultural modification such as remediation of infrastructure to eliminate access, moisture/humidity, or food source.
- Use of predator species to eliminate insect-eating species such as nearby bat colonies, martin houses, and so on.
- In areas with nonvenomous snakes, providing rock piles and shelters for insectivorous and rodent-eating reptiles and amphibians in perimeter gardens.

b. Application of Insecticides to Cracks and Crevices

As a general rule, the contractor shall apply all insecticides as "crack and crevice" treatments only (application with a tool or nozzle specifically designed for crack and crevice injection), defined in this contract as treatments in which the formulated insecticide cannot be contacted or is not visible to a bystander during or after the application process.

c. Application of Insecticides to Exposed Surfaces or as Space Sprays

Application of insecticides to exposed surfaces or as space sprays (including fogs, mists, and ultra-low-volume applications) shall be restricted to unique situations where no alternative measures are practical. The contractor shall obtain the approval of the IPM coordinator prior to any application of insecticide to an exposed surface treatment. No surface application or space spray shall be made while tenant personnel are present. The contractor shall take all necessary precautions to ensure tenant and employee safety, and all necessary steps to ensure the containment of the pesticide to the site of application.

d. Insecticide Bait Formulations

Bait and gel formulations shall be used for cockroach and ant management wherever appropriate and must be inaccessible to children. Note that these containerized baits or crack and crevice applications of gel bats are exempt from notification requirements.

e. Monitoring

Sticky traps shall be used to guide and evaluate indoor insect management efforts wherever necessary.

11. Rodent Management

a. Indoor Trapping

As a general rule, rodent management inside occupied buildings shall be accomplished with trapping devices only. All such devices shall be concealed out of the general view and in protected areas so as not to be affected by routine cleaning and other operations. Trapping devices shall be checked on a schedule approved by the IPM coordinator. The contractor shall be responsible for disposing of all trapped rodents and all rodent carcasses in an appropriate manner.

b. Use of Rodenticides

In exceptional circumstances, when rodenticides are deemed essential for adequate rodent management inside occupied buildings, the contractor shall obtain the approval of the IPM coordinator prior to making any interior rodenticide treatment. All rodenticides, regardless of packaging, shall be placed in locations not accessible to children, pets, wildlife, and domestic animals, and in EPA-approved, tamper-resistant bait stations. As a general rule, rodenticide application outside buildings shall emphasize the direct treatment of rodent burrows wherever feasible.

c. Use of Bait Stations

Frequency of bait station servicing shall depend upon the level of rodent infestation. A suggested minimum is at least one time per month. All bait boxes shall be maintained in accordance with EPA regulations, with an emphasis on the safety of nontarget organisms. The contractor shall adhere to the following five points:

i. All bait stations shall be placed out of the general view, in locations where they will not be disturbed by routine operations.

ii. The lids of all bait stations shall be securely locked or fastened shut.

iii. All bait stations shall be securely attached or anchored to the floor, ground, wall, or other immovable surface, so that the station cannot be picked up or moved.

iv. Bait shall always be placed on mounting rods within the baffle-protected feeding chamber of the station and never in the runway of the station.

v. All bait stations shall be labeled on the inside with the contractor's business name and address, emergency phone number, rodenticide type, and active ingredient, and dated by the contractor's employee at the time of installation and each servicing.

12. Structural Modifications and Recommendations

Throughout the term of this contract, the contractor shall be responsible for advising the IPM coordinator about any structural, sanitary, or procedural modifications that would reduce pest food, water, harborage, or access. The contractor shall be responsible for adequately suppressing all pests included in this contract regardless of whether the suggested modifications are implemented. The contractor will not be held responsible for carrying out structural modifications as part of the pest management effort. However, minor applications of caulk and other sealing materials by the contractor to eliminate pest harborage or access may be approved by the IPM coordinator on a case-by-case basis. The contractor shall obtain the approval of the IPM coordinator prior to any application of sealing material or other structural modification.

13. Program Evaluation

The IPM coordinator will continually evaluate the progress of this contract in terms of effectiveness and safety and will require such changes as are necessary. The contractor shall take prompt action to correct all identified deficiencies.

14. Quality Control Program

The contractor shall establish a complete quality control program to ensure the requirements of the contract are provided as specified. Within five working days prior to the starting date of the contract, the contractor shall submit a copy of his program to the IPM coordinator. The program shall include at least the following items:

a. Inspection System

The contractor's quality control inspection system shall cover all the services stated in this contract. The purpose of the system is to detect and correct deficiencies in the quality of services before the level of performance becomes unacceptable and/or the IPM coordinator identifies the deficiencies.

b. Checklist

A quality control checklist shall be used in evaluating contract performance during regularly scheduled and unscheduled inspections. The checklist shall include every building or site serviced by the contractor as well as every task required to be performed.

c. File

A quality control file shall contain a record of all inspections conducted by the contractor and any corrective actions taken. The file shall be maintained throughout the term of the contract and made available to the IPM coordinator upon request.

d. Inspector(s)

The contractor shall state the name(s) of the individual(s) responsible for performing the quality control inspections.

Forms

The forms on the following pages are intended to help school administrators and pest managers with recordkeeping and inspection activities. They include:

Sample Notification Letter for Parents or Guardians in English and Spanish (pages 25 and 26)
This sample letter can be modified for the school or childcare provider to use in generating a list of parents and guardians who want to be notified of each pesticide application. It should be sent out at the beginning of each school year.

Sample Pest Control Information Sheet (page 27)
This sheet can be used to notify staff and parents and guardians of pesticide applications.

Sample Notice of Pesticide Application (page 28)
The posting required by the legislation must be at least 8½ inches by 11 inches and in place 72 hours prior to and for 48 hours after any pesticide applications.

IPM Pest Sighting Log (page 29)
A pest sighting log should be kept at each facility, building, floor, or room, whichever is most practical with your specific IPM plan. An individual (the district-wide IPM coordinator or building coordinator) should be identified to keep this document and be responsible for it. All employees in the given area should know who this person is and report any pest sightings accordingly. The pest manager reviews this document at the beginning of each visit and responds appropriately. The pest manager should record any treatments that are conducted on this document. Review of this form should be included as part of the pest control operator's periodic inspection process. This function may also be performed via email to the IPM coordinator or through an electronic work order system.

IPM Cafeteria Inspection Checklist (pages 30–31)
Because food handling areas tend to be the source of many pest infestations, a separate inspection form is provided for cafeterias. The pest manager can use this document to ensure a thorough inspection is completed. One of these checklists should be completed during each inspection. The pest manager should not limit the inspection solely to what is indicated on the checklist. The pest manager's comments on the checklist should be reviewed by the IPM coordinator and appropriate action taken.

Sample Notification Letter for Parents or Guardians

(To be sent to all parents or guardians of students enrolled in the school or childcare at the beginning of each school year.)

The _____ [school district or childcare provider] uses an integrated pest management (IPM) approach for managing insects, rodents, weeds, and plant diseases. Our goal in using this approach to pest management is to protect every student from pesticide exposure. Our IPM approach focuses on making the building and grounds an unfavorable habitat for pests by removing food and water sources and eliminating their hiding and breeding places. We accomplish this through routine cleaning and maintenance. We routinely monitor the building and grounds to detect any pests that are present. The pest monitoring team consists of our building maintenance, office, and teaching staff and includes our students. Pest sightings are reported to our IPM coordinator, who evaluates the "pest problem" and determines the appropriate pest management techniques to address the problem. The techniques can include increased sanitation, modifying storage practices, sealing entry points, physically removing the pest, etc.

From time to time, it may be necessary to use pesticides registered by the U.S. Environmental Protection Agency to manage a pest problem. A pesticide will only be used when necessary and will not be routinely applied. When a pesticide application is necessary, the school will try to use the least toxic product that is effective. Applications will be made only when unauthorized persons do not have access to the area(s) being treated. Notices will be posted in these areas 72 hours prior to application and for two days following the application.

Parents or guardians of students enrolled in the school/childcare may request prior notification of specific pesticide applications made at the school. To receive notification, you must be placed on the school's notification registry. If you would like to be placed on this registry, please notify the district/childcare provider in writing. Please include your email address if you would like to be notified electronically.

If a pesticide application must be made to control an emergency pest problem, notice will be provided by telephone to any parent or guardian who has requested such notification in writing. Exemptions to this notification include disinfectants and antimicrobial products; self-containerized baits placed in areas not accessible to students; gel-type baits placed in cracks, crevices, or voids; and swimming pool maintenance chemicals.

Each year the district will prepare a new notification registry.

If you have any questions, please contact _____, IPM coordinator.

Sincerely,

Carta de Notificación para Padres y Tutores

(Para ser enviada a todos los padres y turores de los estudiantes matriculados en la escuela al comienzo de cada año escolar.)

El Distrito Escolar _____ utiliza el método integrado de control de plagas (Integrated Pest Management, IPM por sus siglas en inglés) para el manejo de insectos, roedores y mala hierba. Nuestra meta es proteger a cada estudiante a la exposición de pesticidas utilizando este método. El método IPM se enfoca en hacer del edificio escolar y sus alrededores un hábitat no favorable para estas plagas al remover sus fuentes de alimento y agua y eliminando los lugares donde se esconden y reproducen. Esto se logra a través de una rutina de limpieza y mantenimiento. Con regularidad se inspeccionan el edificio y sus alrededores para detectar si hay plagas presentes. El grupo de control d plagas compone del personal de mantenimiento del edificio, de oficina y profesores y maestros e incluye a nuestros estudiantes. De detectar la presencia de plagas, se informa al coordinador del IPM, el cual evaluará y determinará la(s) técnica(s) apropiada(s) para manejar dicho problema. Las técnicas pueden incluir incrementar la limpieza, modificar las prácticas de almacenamiento, sellar puntos de entrada, físicament remover la(s) plaga(s), etc.

De tiempo en tiempo, puede haber la necesidad de utilizar algún pesticida registrado por la Agencia de Protección Ambiental (EPA) para manejar y/o controlar el problema de plagas. En estos casos, se utilizará solamente cuando sea necesario sin aplicarlo con regularidad y solo se usará la cantidad mínima que sea efectiva. Las aplicaciones se harán cuando no haya personal no autorizados en las áreas donde se utilizará el producto tóxico. Notificaciones serán puestas en las áreas que serán tratadas 72 horas antes de la aplicación y se dejarán por dos (2) días después del tratamiento.

Los padres o tutores de los estudiantes matriculados pueden solicitar que se les envíe una notificación previa de los pesticidas específicos que se aplicarán en la escuela. Si desean recibir esta notificación, sus nombres deben aparecer en la lista del registro de notificación de la escuela. Si deseen estar en la lista del registro, tienen que notificarlo al Distrito Escolar por escrito. Favor de incluir su dirección del correo electrónico si desea ser notificado (a) electrónicamente.

En caso de tener que aplicar algún pesticida para controlar una emergencia de plaga(s), la notificación se proveerá por teléfono a los padres o tutores que hayan solicitado dicha información por escrito. Las excepciones a esta notificación incluyen: desinfectantes y productos antibacteriales y microbiales, carnadas en contenedores cerrados puestos en áreas no accesibles a estudiantes, carnada tipo gelatina que se coloca en rendijas y grietas, y los químicos que se utilizan para el mantenimiento de las piscinas.

Cada año, el Distrito Escolar preparará un nuevo registro de notificaciones.

Si tiene alguna pregunta, favor de comunicarse con _____, Coordinador IPM.

Atentamente,

Sample Pest Control Information Sheet

(This sheet will work as a prior notification of specific pesticide applications made at the school or childcare. It is not required to be any specific size. It may be made available in printed form or transmitted electronically to all affected parties.)

Sample Pest Control Information Sheet for _____
(NAME OF SCHOOL DISTRICT/CHILDCARE OR BUILDING)

A pest inspection and pesticide application have been scheduled for _____.
(DATE OF APPLICATION)

This school district/childcare utilizes an integrated pest management program, applying appropriate pesticides only when needed. Our applicators will select the most appropriate pesticide(s) from the following list of pesticides to control pests identified during their inspections. Not every pesticide listed maybe used.

Pesticides that may be used (enter brand names and EPA Registration Numbers for any pesticide that may be used):

BRAND NAME	EPA REGISTRATION NUMBER
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

For additional information, contact _____
(APPLICATOR NAME)

_____
(APPLICATOR ADDRESS)

_____

_____
(APPLICATOR PHONE NUMBER)

This information is being provided to all staff and to parents and guardians who have requested this information to meet the requirements of Act 36 of 2002.

Sample Notice of Pesticide Application

A pesticide application is planned for the location(s) listed on this sign for

_____

(DATE)

Do not enter treated areas from

_____ **until** _____

(DATE AND TIME) (DATE AND TIME)

Location(s)

_____

_____

_____

_____

For more information, contact:

_____

(NAME)

_____

(ADDRESS)

_____

(PHONE)

Date posted/by _____ _____

Date posted/by _____ _____

This sign is required by Act 36 of 2002 and must be posted at least 72 hours prior to any nonemergency pesticide application and remain in place for at least 48 hours following the application. For emergency pesticide applications, this sign must be posted at the time of the application and remain in place for at least 48 hours from the conclusion of the application. To be removed by authorized personnel only.

IPM Pest Sighting Log

(This form may be copied as needed.)

Facility: _____

To Be Filled Out by School Official			To Be Filled Out by Pest Manager		
Location of Sighting (Bldg. Number/Specific Location)	**Type of Pest(s) Sighted**	**Date**	**Location of Sighting (Bldg. Number/Specific Location)**	**Type of Pest(s) Sighted**	**Date**

IPM Cafeteria Inspection Checklist

(This form may be copied as needed.)

School/childcare name: _____ **Date/time of inspection:** _____ **Inspector:** _____

Condition	Satisfactory	Unsatisfactory	Comments for Facilities/Maintenance
Building Exterior			
1. Garbage storage area			
2. Garbage handling system			
3. Perimeter walls			
4. Perimeter windows/openings			
5. Roof areas			
6. Parking lot and/or drainage areas			
7. Weeds and surrounding landscape			
8. Rodent-proofing			
9. Other			
Building Interior			
1. Walls			
2. Floors			
3. Ceilings			
4. Floor drains			
5. Lighting			
6. Ventilation/air handling equipment			
7. Other			
Food Storage			
1. Dry food storage area			
2. Damaged/spoiled dry food			
3. Empty container storage			
4. Refrigerated areas			
5. Overall sanitation			
6. Other			

(Continued on next page)

Condition	Satisfactory	Unsatisfactory	Comments for Facilities/Maintenance
Food Preparation/Distribution Areas			
1. Counter and surface areas			
2. Food serving lines			
3. Spaces around appliances/equipment			
4. Other			
Other Kitchen Areas			
1. Dishwashing areas			
2. Garbage/trash areas			
3. Tray return area			
4. Storage area for pots/pans/plates			
5. Other			
Utility Areas and Bathroom			
1. Sinks and toilet			
2. Custodian's closet/work area			
3. Other			
Lunchroom Area			
1. Tables/chairs			
2. Office areas			
3. Vending machine area			
4. Other			

Recommendation to cafeteria employees to aid in pest prevention: _____

_____

Reviewed by _____ (NAME) Title _____ Viewed on _____ (DATE)

Action taken _____

Special Topics for Pennsylvania Schools and Childcares

Asthma, Pests, and Pesticides

Asthma is a chronic (long-term) disease with no known cure that causes inflammation of the lungs' airways. Symptoms of asthma include wheezing, coughing, feeling of tightness in the chest, difficulty breathing, and itching of the neck, throat, and ears. While the causes of asthma are not fully understood, a combination of genetic susceptibility and environmental factors is involved. Although we cannot control our genetic makeup, we can help prevent asthma attacks by paying attention to the environmental conditions that irritate lungs and trigger an attack.

Why Be Concerned?

As of 2015, according to the U.S. Centers for Disease Control and Prevention (CDC), approximately 24 million Americans have been diagnosed with asthma, and it is the most common chronic childhood disease—afflicting more than six million children nationally and more than 380,000 children in Pennsylvania. The asthma rates among school-aged children in Philadelphia (14.4 percent) are much higher than the rates for Pennsylvania (9.8 percent) and the nation as a whole (7.8 percent). Asthma is the leading cause of school absences, which also results in parents missing work to stay home with their sick children. In Philadelphia, 16,000 children visit emergency rooms each year for asthma-related symptoms. African American and Hispanic/Latino children have asthma rates two to three times that of white or Asian children. It is important to understand that uncontrolled asthma can be fatal. However, illness from asthma attacks can be prevented by knowing what triggers it.

Asthma Triggers

Asthma attacks are usually started by exposure to certain substances called triggers. Triggers are either allergens or lung irritants. Airborne allergens are substances that cause an allergic reaction, such as pollen, animal dander, cigarette smoke, aerosols, or mold. Chemical lung irritants include pesticides, perfumes, air fresheners, candles, and household and industrial cleaning products. The aging infrastructure of our homes and schools, which can negatively contribute to things such as water leaks and pest presence, also plays a role in exposure to asthma triggers. Repeated exposure to allergens or irritants, such as cockroach and/or mouse allergens, can "sensitize" people, making them more likely to experience allergic reactions. Awareness of asthma triggers can help you take steps to reduce them, thereby preventing asthma symptoms, attacks, and even death.

Pests Trigger Asthma

Pests are unwanted creatures that invade our homes, schools, and childcares. Once they have gotten inside, some of these pests—notably, mice, rats, and cockroaches—can contribute to an asthma attack. In fact, research is under way to determine if these pests can actually cause asthma to develop. The largest major factors contributing to asthma in urban-dwelling children in the northeastern United States have been found to be exposure to mouse and cockroach allergens. Both shed allergens; mice in their urine, and cockroaches primarily in their feces. Since mice dribble "microdots" of urine continuously as they move, large amounts of allergens are released. Studies of mice in schools have found mouse allergens in over 90 percent of schools surveyed and at levels up to 600 times higher than found in homes. Cockroaches shed skins and leave feces behind, and when they are dead, their bodies turn into dust—all things that can trigger an asthma attack. Pesticide sprays or total release foggers

(TRF, also known as "bug bombs") that are sometimes used to combat roaches can also irritate lungs and potentially cause an attack, so they are not recommended for use. Allergens can persist for up to six months after pests are controlled via recommended and legal IPM methods; deep cleaning is required to remove these allergens. The use of a high efficiency particulate air (HEPA) vacuum is recommended. Disinfectants are not recommended since they have no effect on allergens.

Pesticides and Human Health

Pesticides are substances designed to kill, control, or repel pests, including insects, rodents, weeds, and molds. The U.S. EPA lists pesticides as one of four environmental pollutants that may influence the induction and exacerbation of asthma symptoms. Pesticides do this by irritating the lungs as they are breathed in. Commonly used pesticides have been linked to cancer, birth defects, reproductive disorders, and neurological, kidney, and liver damage in laboratory tests with animals. To be safe, it is important to limit children's exposure to toxins of all kinds, including pesticides. Rodenticides, a type of pesticide designed to kill rodents, should never be used in areas to which children have access. They are especially risky because rodents (such as mice and rats) are mammals just like humans, and anything that can kill them can harm us. Additionally, children are not just little adults. They "live low" to the ground, making access to rodenticides, which are usually placed at floor level, risky. Children's developmentally appropriate movements, such as crawling and hand-to-mouth behaviors, also increase the likelihood of access and exposure to pesticides, including rodenticides and the chemicals in sprays/foggers that settle to the floor. Children require smaller doses than adults to have an adverse reaction and cause harm because children breathe, eat, and drink more pound per pound than adults do, and they have developing systems and organs that cannot detoxify substances as well as adults' systems. Pesticides must be used in accordance with their EPA-approved label directions, including that they are labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and SDS for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label. **Pennsylvania law allows pesticide applications in schools and childcares only by certified applicators, registered technicians, or noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must be posted in an area of common access for applications made at or in a school building at least 72 hours prior to and for 48 hours after the application. For applications made on school grounds, the sign must be posted at the place to be treated at least 72 hours prior to and for 48 hours after the application. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied in a school building or on school grounds where students are expected to be present for normal academic instruction or extracurricular activities.**

What Can You Do to Safely Control Pests?

Integrated pest management is an approach to pest control that focuses on eliminating the root causes of pest problems and using the safest, most effective methods available to get rid of active infestations. IPM prevents pests by using a combination of design and maintenance practices and physical, mechanical, and chemical methods. Because IPM focuses on prevention, it is more effective than a reactive, spray-based approach to pest control, and it reduces the need to use pesticides. This manual will provide you with information and "a toolkit" to apply safe and effective IPM methods and protocols in your school and childcare.

Indoor Air Quality

Maintaining good indoor air quality and reducing asthma triggers is part of integrated pest management. Indoor air quality assessments, often conducted as walkthroughs of facilities, also examine ventilation systems, cleaning and sanitation, chemical use and storage, food service, waste management, and other issues. The U.S. EPA developed the Tools for Schools program to make these processes widely available. It has been used by thousands of schools over the last decade. The entire kit may be downloaded from **www.epa.gov/iaq-schools/indoor-air-quality-tools-schools-action-kit**. A mobile app of the checklists, etc., is available from **www.epa.gov/iaq-schools/school-iaq-assessment-mobile-app**. More info about indoor air quality and asthma management in schools is available at **www.epa.gov/iaq-schools**.

Beneficial Insects and Pollinators

IPM considers not only pests but other organisms in the environment that are considered beneficial. IPM practices should minimize harm to these beneficial organisms. This chapter delves into the biology of one type of beneficial insect, the pollinators, but the same practices employed to protect pollinators, such as the use of predators and parasites of pests, also protect other beneficial organisms.

Pollination is defined as the process of transferring pollen from the male (anther) to the female (stigma) part of the flower. Without the process of pollination, flowering plants would not be able to reproduce. While some plants rely on wind and water for their reproduction, the majority of species interact with animals for pollination. About 70 percent of crops depend on insect pollination for fruit and seed production. This means that animal pollination is responsible for providing us with a wide variety of foods.

Common animal pollinators include organisms in different groups, such as butterflies, flies, wasps, bats, and birds, among others. However, bees are the most important pollinators of plants in natural, agricultural, and urban environments. Conserving bees is extremely important for plant reproduction, including the plants that produce the food that we eat. For example, bees are responsible for the pollination and production of apples, pears, nuts, strawberries, peppers, tomatoes, squash, blueberries, and melons. Therefore, protecting bees and helping them to increase their populations is essential for agricultural production in Pennsylvania.

Biology and Natural History

Bees are a group of insects that comprise close to 20,000 species worldwide, and they are found on all continents except for Antarctica. Unlike ants, not all bee species are social. In fact, only 10 percent of all bee species exhibit social behavior. All other bee species are solitary, which means that there is only one female in each nest, and this female does all the work (nest construction, pollen and nectar collection, and egg laying). Three main facts about bees make them the key pollinators of a great diversity of flowering plants:

1. **Bees must feed from flowers.** Bees are a group of insects closely related to sand wasps **(FIGURE A.1)**. While sand wasps (and other wasps and ants) are "carnivorous" and eat other insects to obtain necessary proteins and fats, bees rely exclusively on flowers to fulfill all their dietary needs. Bees use pollen, as a source of protein, and fats and nectar, as sources of carbohydrates. Therefore, bees are called "vegetarian" wasps. The only two exceptions to the "vegetarian bee rule" are (1) some tropical stingless bee species that eat carrion as a source of protein, and (2) kleptoparasitic species that do not collect any pollen because they lay their eggs on the pollen masses made by other bees. But the real importance of this point is that all bees must visit flowers to receive a complete and balanced diet for themselves and for their young.

WIKIPEDIA

FIGURE A.1. Sand wasps are the closest relatives to bees. They nest underground and hunt other insects.

ZACHARY HUANG

FIGURE A.2. Branched hairs are specialized for pollen collection on the bee's body.

ANTHONY VAUDO

FIGURE A.3. Bumble bees have pollen baskets, also known as corbicula, on their hind legs.

ANTHONY VAUDO

FIGURE A.4. Burrowing bees have brushlike tufts of long hairs, called scopa, on their hind legs.

2. **Bees have specialized structures to collect pollen.** Another important feature that makes bees specialized pollinators is that they have a number of structures to specifically collect pollen. These structures help with the successful transfer of pollen grains from one flower to the other. All bees have branched hairs on their bodies **(FIGURE A.2)**. These featherlike hairs are statically charged and facilitate the attachment of pollen grains to the bee's body. In addition, bees have specialized structures to store pollen while foraging. Honey bees and bumble bees have a basket on their hind legs (called corbicula) where they store wet pollen while visiting flowers **(FIGURE A.3)**. Other bee species have long hairs on their legs, while still other species have these long hairs on their armpits or the underside of their bellies **(FIGURES A.4, A.5, A.6)**. All these structures make bees excellent at transferring pollen from one flower to another and make them specialized pollinators.
3. **Bees and plants have close evolutionary histories.** There is a strong and long evolutionary history between bees and flowering plants as a result of their obligatory relationship. This relationship extends back 120 million years. Bees and plants co-radiated, meaning that bees facilitated the diversification of plants and vice versa. Even though many other groups of insects pollinate plants and crops, bees are unique in their close and long-lived relationship with flowering plants. This makes them highly specialized as pollinators.

ANTHONY VAUDO

FIGURE A.5. Sweat bees collect pollen in the long hair located in their armpits.

ANTHONY VAUDO

FIGURE A.6. Leaf-cutting bees collect pollen using the long hairs under their bellies.

Table A.1. Key Morphological Characters to Differentiate Floral Visitors Such as Bees, Wasps, and Flies

	Bees	Wasps	Flies
Wings	Four	Four	Two
Body Shape	Hourglass and cylindrical abdomen	Long, slim, with a marked "waist"	Stout with a less obvious waist
Head	Round	Round	Triangular
Antenna	Medium to very long	Medium	Very short
Stinger	Present	Present	Absent
Hairs	Many; very hairy	None	Few; can be very long
Pollen Collection	Present	Absent	Absent

KATHY DEMCHAK, PENN STATE

FIGURE A.7. Honey bee (*Apis mellifera*).

MARGARITA M. LÓPEZ-URIBE, PENN STATE

FIGURE A.8. Bumble bee.

KATHY DEMCHAK, PENN STATE

FIGURE A.9. Sweat bee.

Bee Identification

Because bees feed exclusively from pollen and nectar, they are most commonly found on flowers. They can often be confused with other common flower visitors such as flies and wasps. **TABLE A.1** shows some of the key differences between bees, wasps, and flies.

Common Bee Species

There are more than 4,000 bee species in North America, and about 450 of those live in Pennsylvania. Below are common bees that you may see in your garden.

Honey Bees (*Apis mellifera*), FIGURE A.7

These social bees are not native to North America. They live in large groups that can reach tens of thousand individuals in one nest. Honey bees are the most important managed pollinators of crops. They are used for not only pollination but also production of other products such as honey and wax.

Bumble Bees (*Bombus* spp.), FIGURE A.8

These hairy native bees are social, but their groups are much smaller with only a couple of hundred individuals in each nest. Because of their large body and ability to buzz pollinate (by vibration of anthers), they are excellent pollinators of crops such as tomatoes, peppers, and blueberries. Roughly 20 species are found in Pennsylvania.

Sweat Bees (Family Halictidae), FIGURE A.9

This group of bees comprises a large number of species (around 80 in Pennsylvania). Most of them are very small, but they are highly abundant in most ecosystems in North America. Many species are solitary, but some groups have highly social species. They get their name because some species are attracted to the salts in human sweat.

Mining Bees (Family Andrenidae),

FIGURE A.10

These solitary native bees are abundant in the spring. They usually emerge with the first plants in bloom early in the year. Their name refers to their nesting habits—these bees nest in the soil by excavating tunnels underground. Mining bees are important pollinators of early blooming crops such as apples and strawberries.

Cellophane Bees (Family Colletidae),

FIGURE A.11

This is another group of solitary, early spring bees that nest underground. These bees get their name because they line their cells (cavities that females construct inside the nest; in solitary bees, the female provisions the cell with nectar and pollen, lays the egg, and then closes the cell) with a secretion that looks like cellophane when it dries out. This layer protects the developing larvae from water and underground pathogens.

Squash Bees (*Peponapis pruinosa*),

FIGURE A.12

These solitary ground-nesting bees specialize on the pollen of plants from the genus *Cucurbita* (pumpkins and squash). They are native from Mexico and have followed the domestication of these plants into North America. They start foraging as soon as the sun rises, and they are only active during the four to six weeks of bloom of *Cucurbita* plants.

Management Options for Enhancing Pollinators

Natural areas, crops, and urban/rural gardens can provide suitable habitat for bee pollinators. Below are some simple tips you can use to help maintain and enhance the population of bees in your gardens. Most of these tips may also be beneficial practices and adapted for the needs of other native pollinators, including butteries, flies, wasps, bats, and birds. For more information, consult with your county extension office, Pennsylvania Game Commission, or the USDA Natural Resources Conservation Service.

1. **Plant your own pollinator garden.** Providing food for bees is one of the best of ways to help enhance pollinators. Keep the following in mind when planning a pollinator-friendly garden:
   - Plant at least 10 to 20 plant species in your garden. Remember that flowering trees and

KATY EVANS

FIGURE A.10. Mining bee.

ALBERTO LOPEZ

FIGURE A.11. Cellophane bee.

MARGARITA M. LÓPEZ-URIBE, PENN STATE

FIGURE A.12. Squash bees.

shrubs are important sources of food, especially early in the season.

- Use a variety of plants that flower from early spring until the first frost.
- Design your garden to have clumps of flowers at the same time. Clustered flowers make it easier for pollinators to locate plants!

2. **Include native plants when possible.** Native plants have evolved along with native pollinators, making them generally the most beneficial to these insects. Choose native plants that are adapted to the soil, light, and moisture conditions in your garden and you'll help pollinators and make your garden care easier.
3. **Some weeds are nutritious.** Do not remove all the weeds from your lawn. Some of them, such as white clover and dandelions, are important food sources for pollinators when other plants are not in bloom.
4. **Reduce the use of pesticides.** Even though pesticides may be necessary for pest control, they can harm pollinators. Try to keep pesticide use to a minimum, and always follow the recommendations of the label. If you need to use pesticides, choose ones with the lowest risk to pollinators (this information is usually on the label). Spray in the evening or before bloom to avoid direct pesticide exposure while pollinators are flying.
5. **Create nesting habitat.** In addition to planting a garden, bees need places to nest. Different species use different habitats. Here are a few things you can do to help provide nesting habitat for them:
   - Let a corner of your school yard or backyard go "wild." Pollinators can find water and shelter in these wild areas. A wooded area, hedgerow, or unmowed "mini-meadow" will provide shelter, additional food resources, and nesting areas (bare soil, twigs).
   - Leave some leaf litter and plant cover on the ground over the winter to provide spots and more insulation for pollinators to overwinter.
   - Build a bee hotel by using nesting blocks **(FIGURE A.13)** for stem nesting bees, such as mason bees and small carpenter bees. Place them in a protected area (away from direct sunlight and rain) and facing southeast if possible.
6. **Provide a source of water.** Even though most pollinators get hydrated from the nectar in flowers, they also need water. Also, some bees use water to wet the soil when they are building their nests underground. Help them by providing a shallow basin of water set on the ground or by letting a hose or faucet drip a bit to form a damp area.

MARGARITA M. LÓPEZ-URIBE, PENN STATE

FIGURE A.13. Bee hotels for stem-nesting bees. Box filled with cardboard straws (left). Wood block with holes for holding paper straws of different diameters (right).

Pests

Pests are any living organisms that negatively affect humans and their property. Pest organisms may include weeds, fungi, bacteria, insects, rodents, and other organisms. In school facilities, the most common pests in buildings are insects and rodents. In exterior areas such as ornamental plantings, sports fields, and lawns, pests may include weeds, plant diseases, and insects, among others.

TABLE A.2 lists of many of the insect, spider, and rodent pests sometimes found in and around Pennsylvania schools. Not all pests found in and around schools have been included on this list, nor are all pests on the list necessarily found in any given school. In addition, not all pests on the list are included in this manual. Those described in this manual have a page number after their heading. The others are listed here to narrow down the search for further information concerning pest species.

Other groups of pests that are not listed but occasionally invade schools are parasitic bird mites, ground beetles, and moths attracted to lights. Additionally, the list does not include potential pests like raccoons, pigeons, starlings, sparrows, Canada geese, chipmunks, groundhogs, or deer.

Information about pests not included in this manual can be obtained from Penn State Extension educators, pest management professionals, verified websites, or other sources found in the references and additional resources listed at the end of this manual. Keep in mind that reliable sites are more likely to be from universities (.edu) and government (.gov).

IPM strategies depend on proper identification of the pest you wish to manage. Misidentification leads to improper treatment strategies and wastes time and money. Even pests of similar types often have different habits, habitats, food requirements, and management strategies.

Penn State Extension educators and other IPM professionals can provide help with identification and information needed to properly manage various pests. They can also make recommendations about treatments, which may include contracting with a pest management professional.

Table A.2. Pests Found in and around Schools

Ants—Hymenoptera (page 41)	
Carpenter ant	*Camponotus* spp.
Larger yellow ant	*Lasius interjectus*
Odorous house ant	*Tapinoma sessile*
Pavement ant	*Tetramorium caespitum*
Pharaoh ant	*Monomorium pharaonis*
Thief ant	*Solenopsis molesta*
Bed Bugs—Cimicidae (page 47)	*Cimex lectularius*
Bees, Hornets, and Wasps—Hymenoptera (pages 34 and 138)	
Bees	*Apis* spp., *Bombus* spp.
Hornets	*Dolichovespula maculata*
Paper wasps	*Polistes* spp.
Solitary wasps	Various species
Yellowjackets	*Vespula* spp.
Cockroaches—Blattaria (page 61)	
American cockroach	*Periplaneta americana*
Brownbanded cockroach	*Supella longipalpa*
Cuban cockroach	*Panchlora nivea**
German cockroach	*Blattella germanica*
Oriental cockroach	*Blatta orientalis*
Pennsylvania wood cockroach	*Parcoblatta pensylvanica*
Surinam cockroach	*Pycnoscelus surinamensis**
Fleas—Siphonaptera (page 73)	
Cat flea	*Ctenocephalides felis*
Human flea	*Pulex irritans*
Flies—Diptera (page 78)	
Blue bottle fly	*Cynomyopsis cadaverina*, *Calliphora* spp.
Cluster fly	*Pollenia rudis*
Fruit fly	*Drosophila* spp.
Green bottle fly	*Phaenicia sericata*
House fly	*Musca domestica*
Moth fly (drain fly)	*Psychoda* spp.
Phorid fly (drain fly)	*Megaselia scalaris*
Landscape Pests	
Borers	
Larvae of moths or beetles	Lepidoptera, Coleoptera
Foliage-feeding insects	
Beetles	Coleoptera
Caterpillars	Lepidoptera
Leaf miners	
Larvae of flies, beetles, or moths	Diptera, Coleoptera, Lepidoptera

continued on next page

*Found in greenhouses and mall plantings in Pennsylvania.

continued from previous page

Plant-Sucking Pests	
Aphids	Homoptera: Aphididae
Lace bugs	Hemiptera: Tingidae
Mealybugs	Homoptera: Pseudococcidae
Scales	Homoptera: Coccidae, Diaspididae
Spider mites	Acarina: Tetranychidae
Thrips	Thysanoptera: Thripidae
Whiteflies	Homoptera: Aleyrodidae
Lawn Pests	
Billbugs	*Sphenophorus* spp.
Chiggers	Acari: Trombiculidae
Hairy chinch bugs	*Blissus leucopterus hirtus*
Snails	Pulmonata: Helicidae
Sod webworms	Crambinae
Spittlebugs	Homoptera: Cercopidae
White grubs	Coleoptera: Scarabaeidae
Lice—Phthiraptera (page 86)	
Body louse	*Pediculus humanus corporis*
Crab louse	*Phthirus pubis*
Head louse	*Pediculus humanus capitis*
Miscellaneous Pests (pages 56 and 106)	
Booklice	*Liposcelis* spp.
Clothes moth	*Tinea pellionella, Tineola bisselliella*
Firebrat	*Thermobia domestica*
House Centipede	*Scutigera coleoptrata*
Silverfish	*Lepisma saccharina*, *Ctenolepisma* spp.
Stored products pests	Coleoptera, Lepidoptera

Mosquitoes—Diptera (page 89)	*Aedes* spp., *Anopheles* spp., and *Culex* spp.
Occasional Invaders	
Boxelder bug	*Boisea trivittatus*
Cluster fly	*Pollenia rudis*
Earwigs	Dermaptera
Elm leaf beetle	*Xanthogaleruca luteola*
Millipedes	Arthropoda: Diplopoda
Multicolored Asian lady beetle	*Harmonia axyridis*
Sowbugs	Crustacea: Isopoda
Western conifer seed bug	*Leptoglossus occidentalis*
Rodents (page 96)	
Black rat	*Rattus rattus*
House mouse	*Mus musculus*
Norway rat	*Rattus norvegicus*
Spiders (page 109)	
Black widow spider	*Latrodectus mactans*
Brown recluse spider	*Loxosceles* spp.
Jumping spider	*Phidippus audax*
Wolf spider	Lycosidae
Yellow sac spider	*Cheiracanthium* spp.
Termites (page 123)	
Eastern subterranean termite	*Reticulitermes flavipes*
Native subterranean termites	*R. hageni*
	R. virginicus
Ticks (page 114)	
American dog tick	*Dermacentor variabilis*
Blacklegged tick (formerly called deer tick)	*Ixodes scapularis*
Lone star tick	*Amblyomma americanum*

Integrated Pest Management for Animals

IPM for Ants

INTRODUCTION

Ants become pests when they invade buildings in search of food or shelter. It is often very difficult and laborious to eliminate most ants from their outside habitat, so management efforts should be aimed at preventing ants from invading structures. Unfortunately, prevention is not always successful and management actions must be implemented.

Although ants are often regarded as a nuisance and can transfer disease, they are beneficial in several ways. Ants are predators of numerous pest insects, including fly larvae and termites. By aerating soil and recycling dead animal and vegetable material, they aid in the formation of topsoil. Ants are also responsible for pollinating plants in some areas. Ants provide a great service to the environment, and management efforts that prevent or suppress ants are preferred over practices that aim to eliminate ants.

IDENTIFICATION AND BIOLOGY

Ants are social insects. They live in colonies whose members are divided into three castes: workers, queens, and males. The workers enlarge and repair the nest, forage for food, care for the young and the queen, and defend the colony. The queen lays eggs and acts as the sole source for new workers and colony growth (although note that depending on the ant species, a colony may have one or multiple queens). The males serve only to mate with new queens when they leave the parent colony before they establish new nests.

Ants pass through four stages of development: egg, larva, pupa, and adult. After mating with males, a queen lays eggs that hatch into blind, legless larvae. The larvae are fed and cared for by worker ants. At the end of the larval stage they turn into pupae, which do not feed. After a short period of time, adult ants emerge from their pupal cases. Most ants develop into workers, although a few develop into new queens and males that will eventually leave the nest to found new colonies.

Many species of ants—most of which differ in their habits and food preferences—can invade a structure. Therefore, it is critical to identify the type of ant you want to manage in order to select the most appropriate strategies. See **TABLE 1.1** for characteristics to help identify commonly encountered pestiferous ant species.

DETECTION AND MONITORING

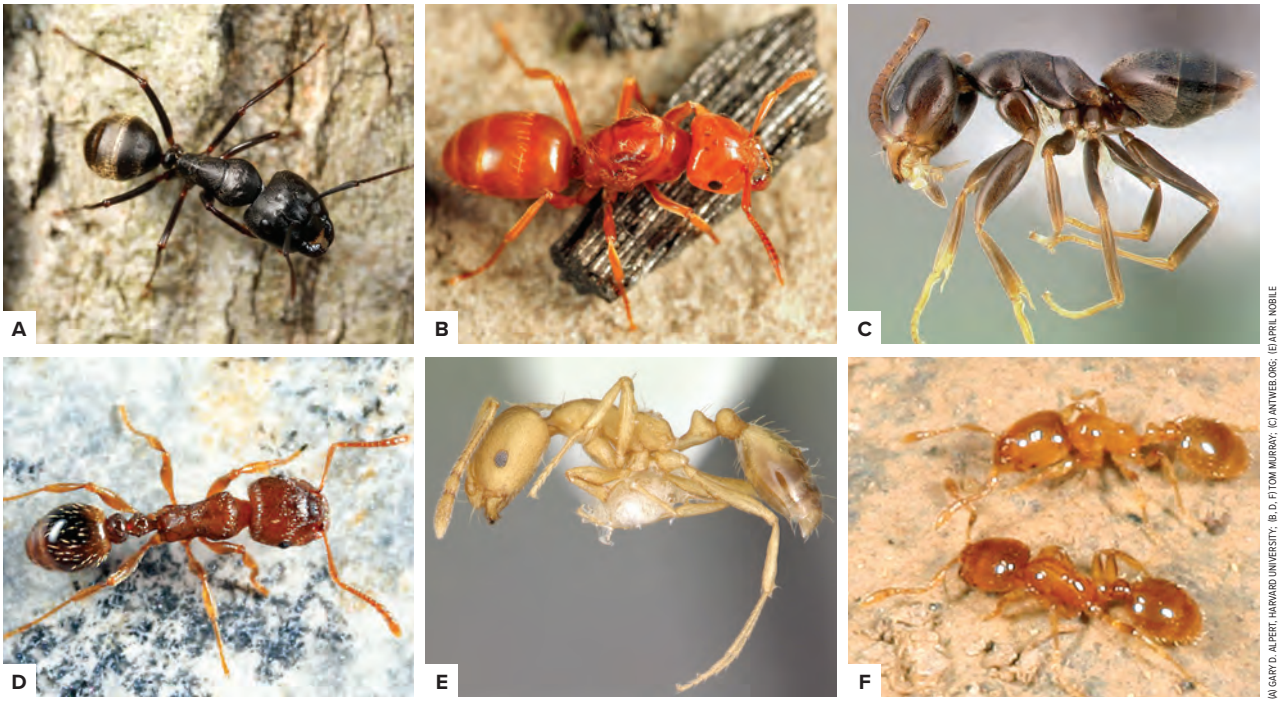
Visual inspection is the most useful monitoring technique for detecting ants, and it can be very useful for preventing a developing infestation. A thorough inspection and prevention program is required to locate the ant source.

- Make a map of the school on which you can note problem areas and areas needing repair. (A fire evacuation base map is ideal.)
- A bright flashlight, kneepads, a digital camera, and a mirror are helpful.
- Carry a caulking gun to seal holes and cracks during inspection to prevent ants from gaining entry to the structure.
- Glue boards or sticky traps placed in areas ants are likely to be found can help with monitoring.
- Keep accurate records during the monitoring program to help formulate an IPM plan and evaluate its effectiveness.
- Talk with kitchen staff and custodians to learn more about the problem from their perspective.

Table 1.1. Common Ant Species That Invade Houses, Schools, and Childcares

Species	Number of Nodes in Pedicel (FIGURE 1.1)	Description of Workers	Habits
Carpenter Ant (*Camponotus pennsylvanicus*), **FIGURE 1.2A**	1	Large, ¼ to ½ inch (6–12 mm) long; shiny dark brown to black; evenly rounded thorax when viewed from the side	Nests in logs, stumps, hollow trees; may nest in moist, rotting wood, foam plastic insulation board, etc.; makes satellite nests; omnivorous; common house invader; prefers honeydew but will feed on plant juices or other insects
Larger Yellow Ant (*Lasius interjectus*), **FIGURE 1.2B**	1	Around 5/32 to 3/16 inch (4–4.5 mm) long; pale yellowish brown; when crushed, smells like citronella	Lives in soil next to foundation, under basement floor, concrete voids, or rotting wood; feeds on honeydew of subterranean aphids and mealybugs
Odorous House Ant (*Tapinoma sessile*), **FIGURE 1.2C**	Apparently 0 (the node is hidden under abdomen)	Around 1/10 to ⅛ inch (2.4 to 3.25 mm) long; brownish to black; emits foul odor (sometimes described as smelling like banana) when crushed	Frequent house invader; nests in a wide variety of places outdoors and inside; multiple queens; colonies are localized; prefers honeydew from aphids, scales, etc., but is an opportunistic species and will feed on other sweets, protein, and grease
Pavement Ant (*Tetramorium* spp.), **FIGURE 1.2D**	2	Around 1/16 to ⅛ inch (2.5 to 4 mm) long; light to dark brown or blackish; head and thorax furrowed by parallel lines	Nests under stones and edges of pavement, in winter will nest in houses in crevices adjacent to a heat source; slow moving; tends aphids for their honeydew; feeds on seeds, insect remains, and greasy materials
Pharaoh Ant (*Monomorium pharaonis*), **FIGURE 1.2E**	2	Small, 1/16 to 1/12 inch (1.5 to 2 mm) long; round; yellowish to red; often confused with thief ant, but has three segments in the clublike structure at the end of the antennae	Nests in any secluded spot; prefers temperatures between 80 and 86°F; frequent house invader; often found around kitchen and bathroom faucets, where it obtains water; feeds on sweets but prefers fatty foods; eats dead insects
Thief Ant (*Solenopsis molesta complex*), **FIGURE 1.2F**	2	Very small, 1/16 inch (1.3 to 0.125 mm) long; round; yellowish; often confused with pharaoh ant but has two segments in the clublike structure at the end of the antennae	Often lives in association with other ants as predator of brood; omnivorous but prefers grease or high-protein foods over sweets; frequent house invader; may nest indoors in cracks and cupboards

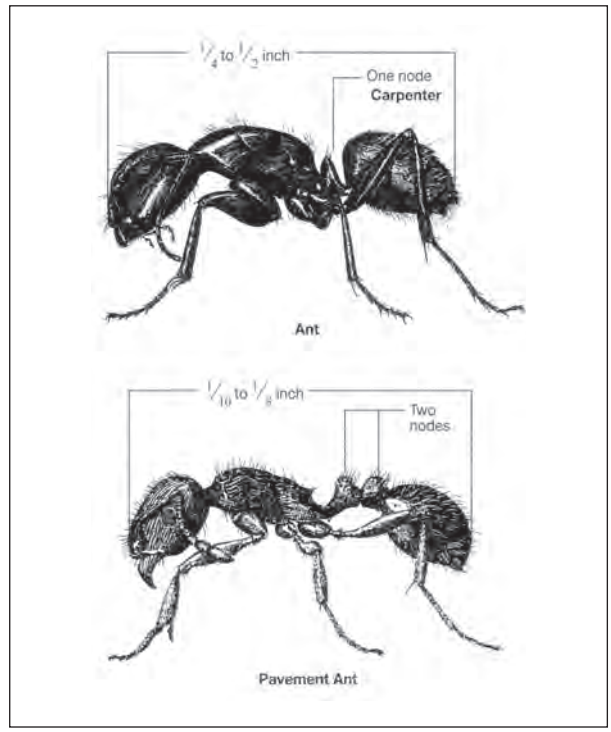
Adapted for Pennsylvania schools by J. Kenneth Long Jr., PA IPM program assistant, October 1999, from the University of Florida School IPM website article "Common House-Invading Ant Species," at schoolipm.ifas.ufl.edu.



(A) GARY D. ALPERT, HARVARD UNIVERSITY; (B, D, F) TOM MURRAY; (C) ANTWEB.ORG; (E) APRIL NOBILE

FIGURE 1.2. Ant species commonly encountered indoors in Pennsylvania: (A) black carpenter ant (*Camponotus pennsylvanicus*); (B) larger yellow ant (*Lasius interjectus*); (C) odorous house ant (*Tapinoma sessile*); (D) pavement ant (*Tetramorium*); (E) pharaoh ant (*Monomorium pharaonis*); (F) thief ants (*Solenopsis*).

- Ants are most likely to be indoor pests in kitchens and food preparation areas.
- An ant infestation may indicate that there has been a change in the methods of storing food or food waste that allows increased food sources for ants. Note how food and food wastes are stored in the area, and whether refuse containers are emptied and cleaned regularly. Inspect recycling bins to ensure recyclables have been cleaned before being placed in bins.
- Ants can be attracted to snacks kept in classrooms or teachers' lounges and to sweet drinks spilled on the floor and other surfaces.
- Carpenter ants are attracted to moist areas. Check any areas where there might be a water leak or moist or rotting wood (including firewood, logs, or stumps outside).



OHIO STATE UNIVERSITY FACT SHEET "ANTS IN AND AROUND THE HOME"

FIGURE 1.1. Carpenter and pavement ants.

MANAGEMENT OPTIONS

Habitat Modification

The environment should be modified to reduce ant entryways and access to food. With quality materials and careful work, the alteration will be permanent and will make a long-term impact on the number of ant invasions.

Indoor Caulking

- Caulk all potential entryways with a silicone caulking compound.
- Make sure surfaces are free of dust, grease, or dirt before applying caulk.
- Use mildew-resistant caulk in moist areas.
- It is not necessary or practical to seal all cracks. Begin with the access point that the current trail of ants is using.
- Always carry caulk when making inspections, and seal as many cracks as time allows, especially those around baseboards, cupboards, pipes, sinks, toilets, and electrical outlets. Silicone caulks are flexible, easy to apply, and long-lasting.
- Use weatherstrip around doors and windows where ants may enter.
- Repair any water leaks and replace moist or rotting wood as needed.

Exterior Caulking

Exterior surfaces are subject to weather and the shifting of building elements relative to one another. Careful selection of caulks or sealants is recommended. See **TABLE 1.2** for help with making appropriate sealant selection.

Sanitation

Sanitation eliminates food for ants. Thorough daily cleaning of school kitchens and food preparation areas is essential.

- Sweep and mop floors.
- Drain all sinks and remove any food debris.
- If children regularly receive snacks in classrooms, these floors should be vacuumed and/or mopped daily.
- Regularly give all food preparation areas a complete cleaning, focusing on areas where grease and food debris accumulate, such as drains, vents, deep fat fryers, ovens, stoves, and hard-to-reach areas behind or between appliances. Thoroughly clean these areas with a powerful vacuum.
- Drains with buildup of organic matter may be food or breeding sites for ants, flies, or other insects. Enzyme cleaners will remove this. Do not use brushes to scrub out floor drains; doing so may release pathogenic (disease-causing) bacteria and contaminate the kitchen.
- At the end of each day, remove from the building all garbage that contains food.

Table 1.2. Characteristics of Caulks and Sealants Used in Pest Exclusion

Material*	Maximum Joint Movement	Surface Compatibility**	Life Expectancy (years)***	Service Temperature	Application Temperature	Paintable
CAULKS						
Oil Based	2%	Nonporous	1–2 (exterior), 10 (interior)	-20–180°F (-30–82°C)	>40°F (4°C)	Yes
Butyl	7.5%	Most, esp. masonry concrete	7–10	-20–200°F (-30–93°C)	>40°F (4°C)	Yes (slow cure)
Latex	2%	Most	3–5 (interior)	-20–150°F (-30–65°C)	>40°F (4°C)	Yes (fast cure)
Acrylic Latex	2%	Most	1–2 (exterior), 3–10 (interior)	-20–180°F (-30–82°C)	>40°F (4°C)	Yes
Urethane Foam	0%	Most	10–20 (if protected)	-20–250°F (-30–120°C)	>70°F (21°C)	Yes
SEALANTS						
Siliconized Acrylic Latex	25%	Most, except plastics	20–30	-20–180°F (-30–82°C)	>32°F (0°C)	Yes
Ethylene Copolymer (Geocel™)	25%	Most, except plastics	10–20	-20–200°F (-30–93°C)	>0°F (-18°C)	Yes
Polysulfide	25%	Varies	10–20	-40–250°F (-40–120°C)	>60°F (15°C)	Unknown
Urethane	25%	Most, except glass	20–30	-40–250°F (-40–120°C)	>40°F (4°C)	Unknown
Silicone	12–50%	Varies	20–30	-65–350°F (-54–175°C)	>0°F (-18°C)	No

*Except ethylene copolymer, materials listed in this column are manufactured and sold by several companies.
**How well the material adheres to different substrates. "Varies" indicates much variability in surface compatibilities among the products within a certain class of material. Manufacturers should be consulted for specific information on the suitability of their products for different uses.
***Materials with shorter exterior than interior life are subject to accelerated breakdown by UV light, oxidation, and weathering.

REPRODUCED FROM "RECOMMENDATIONS FOR SELECTING AND USING CAULKS AND SEALANTS IN PEST MANAGEMENT OPERATIONS" BY ROBERT CORRIGAN, PH.D., WITH THE PERMISSION FROM THE AUTHOR.

- Use soapy water to wash any bottles, cans, wrappings, and other items that have food residues before storing them for recycling.
- If dishes cannot be washed right away, it is very important that they at least be rinsed to remove all food debris.
- Place garbage in sealed plastic bags and then place the bags in a rodent-proof dumpster or other storage receptacle.
- Keep garbage cans and dumpsters as clean as possible to deny food to ants, roaches, flies, mice, and rats.

Proper Food Storage

- Food not kept in the refrigerator should be kept in containers that close tightly. Cardboard boxes are not ant or roach proof.
- Keep particularly attractive substances, like sugar and honey, in the refrigerator.
- Although refrigerator storage is usually safe, ants sometimes get into refrigerators even when the seals appear intact. When this occurs, a light, temporary coating of petroleum jelly on the edge of the refrigerator seal will exclude the ants.
- Screw-top jars are ant proof only if the lid has a rubber seal because some ants can follow the spiral ridges to get into the jar.
- Glass containers with rubber gaskets or plastic containers with tight-fitting, snap-top lids are also ant proof.
- Upon delivery, transfer packaged food into plastic or glass containers. To prevent roach problems, do not bring shipping boxes into the food preparation area. Instead, boxes should be broken down and stored away from the kitchen in a cool area until removed for recycling.
- Advise students and teachers not to leave unsealed food items in their desks or lockers.

- Any food kept in offices or classrooms should be stored in ant-proof containers.
- Storage shelves should be far enough off the floor to facilitate cleaning and reduce the possibility of access by insects or rodents. No supplies should be stored on the floor.

Physical Controls

At times, when only a few ants are noticed foraging in an area, crushing the ants may be effective. However, foragers represent about 10 percent of an ant population, so further management efforts may be needed.

Vacuuming

- Use a strong vacuum with a HEPA filter to vacuum up trails of ants effortlessly and quickly.
- Vacuum up a tablespoon of cornstarch to kill ants in the vacuum bag.
- Carpenter ant colonies living under insulation may be removed by vacuuming.

Detergent Barrier

Temporary "moats" of detergent and water may be useful during heavy ant invasions. Containers of food or food waste that must remain open during working hours can be placed in large, shallow pans filled with water mixed with a small amount of detergent.

Use this technique to protect potted plants from ants that may be attracted to nectar produced by the plant or honeydew produced by plant-feeding insects. Elevate the pot above the detergent and water mixture by placing it on an overturned saucer. Make sure the plant is not in contact with anything that ants could use as a bridge. This will not manage an auxiliary colony that may already be established in the pot.

Chemical Controls

At times, nonchemical methods alone prove insufficient to solve the problem. Integrating a pesticide into your management program may be necessary to gain control of the ant problem.

Pesticides must be used in accordance with their EPA-approved label directions, including that it is labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and SDS for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label. **Pennsylvania law allows pesticide applications in schools and childcares only by certified applicators, registered technicians, or noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must be posted in an area of common access for applications made at or in a school building at least 72 hours prior to and for 48 hours after the application. For applications made on school grounds, the sign must be posted at the place to be treated at least 72 hours prior to and for 48 hours after the application. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied in a school building or on school grounds where students are expected to be present for normal academic instruction or extracurricular activities.**

When treating for ants, use only crack and crevice treatments or containerized baits.

Detergent and Water

When ants invade a classroom or food preparation area, the best emergency treatment is a mixture of dishwashing detergent and water in a spray bottle. This mixture will quickly immobilize the ants, which can then be wiped up with a sponge and washed down the drain. Each classroom, cafeteria, and food preparation area should be equipped with a spray bottle so teachers and staff can safely deal with emergencies. The bottle should be labeled with the proportion of contents and in compliance with school policy for product safety. As with all cleaners and chemicals, it should be stored out of the reach of children.

Boric Acid

Boric acid is one of the most valuable chemical tools in an integrated ant management program. It is formulated as a dust, gel bait, and aerosol. If kept dry, boric acid dust remains effective for long periods of time. Boric acid gel baits are very effective at controlling many species of ants.

- When applying boric acid dust, wear a dust mask to avoid breathing the material.
- Use a bulb duster to apply a light dusting in cracks and crevices. Boric acid should never be applied to large, open areas.
- Boric acid is approved for crack and crevice treatment in kitchen and food preparation areas.
- Boric acid can be dusted into wall voids and spaces behind and under cabinets.

Diatomaceous Earth and Silica Aerogel

These are insecticidal dusts that can be used for ant management. Diatomaceous earth (DE) is made from fossilized diatoms, and silica gel is produced from sand. Both kill insects by desiccation—they abrade the wax and oil on the insect's outer covering, leading to dehydration and death. Although these materials are not directly poisonous to humans, the fine dust travels freely through the air and can be irritating to the eyes and lungs. Use a dust mask, goggles, and any other appropriate personal protective equipment in accordance with the label instructions during application.

DE and silica aerogel are especially useful in wall voids and similar closed spaces. These dusts can be blown into such spaces during construction and remodeling. In finished buildings, they can be applied by drilling tiny holes in the walls and puffing the dust through the holes. Be sure to patch the holes when finished. These dusts also are useful in crack and crevice treatments.

Ant Baits

Baits greatly reduce the amount of pesticide that must be used to kill ants. Foraging ants take the bait back to the nest to feed to other members of the colony, resulting in colony death. Fast-acting baits kill foraging workers quickly, but they are less effective than slow-acting bait and can be taken back to the nest for consumption. Even if the queen is not killed, baits will usually stop an ant invasion. If a colony has been starved by effective sanitation measures, baits will be more readily accepted. Baits should be placed out of the sight and reach of children.

Some ants are very susceptible to baits, while others are less so. There are many reasons for these differences, only some of which we understand. The following points may be helpful if you are having difficulty managing ants with a bait:

- Correct identification of the species of ant is essential because each species differs in its food preferences. Some baits use a sweet attractant, while others use a protein or oily attractant. The attractant used must be preferred by the type of ant you wish to manage. If you cannot determine the type of attractant by looking at the label, call the manufacturer for more information. You also should ask if the company has data to support the efficacy of their product against the ant species you are dealing with.
- After setting out bait, observe to see if the target ant is taking the bait.
- Ant colonies have changing nutritional requirements that can pose problems to baiting. A colony that accepted a protein bait one week may be more interested in a sugar bait the next.
- The nesting and foraging environment can also affect bait acceptance. Ants nesting and foraging in dry areas will be more interested than ants nesting in moist environments in baits with a high water content (such as gel formulations).
- When there are several competing ant species in one area, nontarget ants may accept the bait more readily than the pest ant and, in some cases, prevent the pest ant from getting to the bait.
- Do not spray pesticides when using baits. Bait stations contaminated with pesticide are repellent to ants, and sprays disperse the ant infestation, making it more difficult to place baits effectively.
- Place bait stations along foraging trails, but do not disturb ant trails between the nest and the bait. Killing the ants or disturbing the trails prevents the ants from taking the bait back to the colony to kill nest mates.
- Do not apply bait until an ant problem is noticed. If you use baits preventively, you may attract ants into the building.
- Some baits come packaged in plastic disc "bait stations" with double-sided tape so they can be attached to various surfaces out of view. It is important to remove bait stations once management is attained because the stations may serve as harborage for ants. Some baits are formulated as granules or gels that can be injected into wall voids through small holes. Gel baits can also be placed near ant trails in inconspicuous places where they will not be disturbed.

IPM for Bed Bugs

INTRODUCTION

Pennsylvania and other states have recently seen an increased number of bed bug infestations plaguing residents. As bed bugs infest more homes, they may find their way into schools and childcares. Before this happens, a school district or childcare center needs to be proactive by having in place a detailed integrated pest management plan with policies and procedures describing how to address a bed bug issue. Then, if an issue does arise, the school needs to take the appropriate actions to stop the bed bugs from spreading in the school setting.

Bed bugs are uniquely different from most indoor pests. First, their behavior and biology make them extremely difficult to prevent and eliminate with the usual combination of pest control tools. Therefore, it is vital to engage, educate, and communicate with everyone in the school community. Be sure to include administrators, maintenance and custodial staff, teachers, staff, students, and parents and guardians, and document the education efforts made in the community. Secondly, few things cause such strong emotional reactions as do the suspicion or discovery of bed bugs. Bed bugs illicit "fear and loathing" along with a strong dose of stigma, even though hygiene, sanitation, and "dirt" have nothing to do with bed bug infestations. When bed bugs arrive at school, accusations fly with demands for immediate action, even if ineffective or inappropriate. For school administrators and facilities managers, bed bugs arriving at school can be a recipe for big headaches—from bad publicity to expensive contracted services to litigation. Preparation, protocols, and proactive communication are essential.

Why are bed bugs are making a comeback in apartment buildings, dorm rooms, hotels, hospitals, and homes? People, and the things that they buy, are traveling greater distances and more frequently, causing hitchhiking bed bugs to spread more rapidly. Finding a bed bug in a school can cause anxiety and overreaction; schools are poor environments for bed bugs to become established and create an infestation. Bed bugs have been shown to be unlikely to spread disease, and improper use of pesticides may create a greater danger than the insect itself poses. Chemicals should not be used in schools to control bed bugs. **Note:** The PA IPM Program does not endorse specific products. However, some products have been specially designed for bed bugs, and they are so much more effective than others that they are discussed in this section. The program has no financial interest in any products.

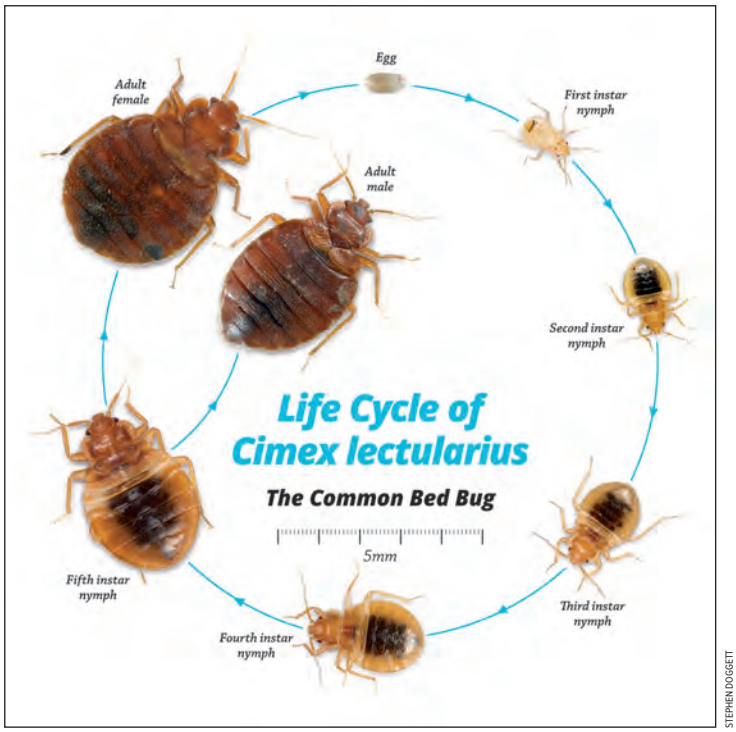
Bed bugs are parasites of humans. Several species are possible, but the most common is *Cimex lectularius,* the common human bed bug. Tropical bed bugs *(Cimex hemipterus)* may be encountered; other species also infest poultry and bats. Bats also have their own bug, *Cimex pilosellus*, and birds have the swallow bug *(Oeciacus vicarius)*. Poultry houses can be infested with *Haematosiphon inodora* and may be a source of bed bugs for children in rural areas. All species are closely related and similar in appearance and behavior. Proper identification of bugs by a professional is important to determine the source. If bats or birds are present in the building, reinfestation is likely; bats and birds must be removed by a Nuisance Wildlife Control Operator. If you have any questions or concerns about wildlife and its removal, please contact the Pennsylvania Game Commission at 717-783-6527. This manual deals with *Cimex lectularius*, the common bed bug.

IDENTIFICATION AND BIOLOGY

Bed bugs range from brown to reddish brown in color, are oval shaped, flattened and paper thin when unfed, and wingless **(FIGURE 2.1)**. Adults can be 3/8 inch long, which is about the size of an apple seed. Immature bed bugs can be as small as 1/16 inch when they first hatch, which is about the size of a poppy seed. Young bed bugs are nearly colorless when they first hatch, but they become bright red in color after a feeding. Although their

NEW YORK CITY DEPARTMENT OF HEALTH AND MENTAL HYGIENE

FIGURE 2.1. Identifying bed bugs.



STEPHEN DOGGETT

FIGURE 2.2. Life cycle of a bed bug.

bite does not hurt at the time, it may develop into an itchy welt similar to a mosquito bite. Bed bugs likely do not transmit disease, but they can cause significant itchiness, anxiety and depression, sleep disturbances, isolation and withdrawal from social interactions, and other stigmas. Secondary infections may occur if the victim scratches the bites. Bed bug infestations can be very difficult and expensive to control.

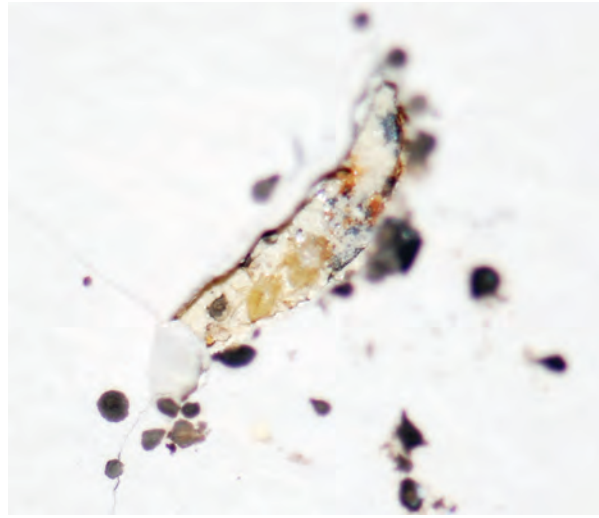
Bed bugs usually hide during the day and only come out to feed during the night. Unlike head lice, they do not live on a person. However, they can hitchhike from one place to another in backpacks, clothing, luggage, books, and other items.

Females lay white, oval-shaped eggs that are about 1/16 inch long into cracks and crevices of their hiding places, called harborages. An adult female bed bug can lay five to seven eggs per week and 200 to 250 eggs in a lifetime. Eggs hatch within six to ten days. Immature bed bugs, or nymphs, molt (or shed their skin) five times before becoming an adult; these stages are called instars **(FIGURE 2.2)**. In order to grow and develop, bed bugs need to feed on blood. Generally, they feed on the blood of humans, but they may feed on the blood of other animals if humans are not available. Bed bugs can live for more than four months without a blood meal.

INSPECTING FOR BED BUGS

Four major signs indicate that bed bugs are present:

- Eggs
- Live bed bugs
- Cast skins **(FIGURE 2.3)**
- Fecal spots



ALEXIS BARBARIN

FIGURE 2.3. Cast skins of bed bugs.

ALEXIS BARBARIN

FIGURE 2.4. Blood stains left on a wall by bed bugs.

ALEXIS BARBARIN

FIGURE 2.5. Bed bugs on a mattress seam.

Bed bugs tend to cluster together in areas called harborages. In harborages, you will find all four signs of bed bugs. Bed bugs must venture out of those harborages to feed. They excrete blood waste immediately after feeding, which may result in red-colored blood smears on upholstery, bedding, etc. **(FIGURE 2.4)**. These are sometimes called "rust stains," but they are fecal digested blood. Most infestations begin around areas where humans spend the most time, such as beds, sofas, and chairs **(FIGURE 2.5)**. Bed bugs have been known to gather in the seams of clothing, shoes, and book bags. Another possible sign of bed bugs is the presence unexplained bites. However, bites often appear different on different people, if they appear at all. Therefore, bites are not a reliable indication of an infestation.

While schools can have bed bugs introduced from the clothes or belongings of staff or students, schools are not a good environment for bed bugs to become established, and actual infestations in schools are rare. People do not sleep overnight in most schools, removing the most common source of food. Childcares, however, will need to inspect cots and, especially, infant cribs weekly. Since bed bugs need a blood meal to molt and grow, and to mate, they find it difficult to thrive and breed in a nonresidential school environment. However, bed bugs will venture out of harborages to feed or disperse during the day, which is how they are usually spotted in schools. Recent research has shown that bed bugs are much more mobile than previously believed.

Many small arthropods and their bites are easily mistaken for bed bugs. Get a positive identification first. Transparent tape (Scotch™ tape) can be used to capture a bed bug sample. Use a strip about 2 inches long, and gently push one end down on the bug, lift up and fold the tape over, trapping the bug between the layers. Do not crush the bug—it makes identification difficult! Record the date, time, place, and conditions of capture. Place the tape in a sealed plastic bag or covered plastic container for storage and transport.

Because it has been so long since bed bugs have been a problem in the United States, even some pest control operators have misidentified bed bugs. Ticks (especially immature larval stages), juvenile cockroach nymphs, spider mites, carpet beetle larvae, and many other insects are often misidentified as bed bugs. Your local Penn State Extension office can help verify and identify bed bugs and other insects (see **extension.psu.edu/county-offices** to find your local office). The Penn State Extension publication "Is Something Biting Me?" and other fact sheets can assist with bite identification and be made available to parents, guardians, and other concerned individuals. Additionally, Rutgers University has good pictures of the appearance of bed bug bites at **njaes.rutgers.edu/bed-bug/photos.php**.

CAN CLASSROOMS BE INFESTED WITH BED BUGS?

Actual bed bug infestations in schools are uncommon. Infant rooms with cribs in childcares or preschool rooms where children nap can become infested. Special needs classes where students are in wheelchairs can be a problem if children have bed bugs at home—the wheel chair can become a harborage and distribution device. More commonly, a few bed bugs will hitchhike to school from an infested home by hiding in a student's clothing or backpack. Bed bugs that hitch a ride to school in one student's backpack could be carried home by another student, making the school a potential hub for bed bugs to spread. This is not a minor concern because bed bugs are very expensive and difficult to eradicate.

MANAGEMENT OPTIONS

An accurate identification of the bed bug species involved is essential to an effective control strategy. Many control failures can be traced to an incorrect identification.

Nonchemical Controls

Classroom Treatments

- Reduce clutter to make inspections and treatments easier.
- Avoid bringing in items such as used furniture or "donations" from homes that could potentially become infested or may already be infested with bed bugs.
- Avoid couches, other upholstered furniture, and "cozy" areas containing cushions, pillows, and other harborage areas, especially in young grades.
- Backpacks, lunch boxes, and other items that travel back and forth to school can be inspected daily and sealed in plastic containers (at both home and school) to prevent bed bugs from being transported from one location to another.
- Store book bags and jackets on hooks, off the floor. Lockers or cubbies may become infested

harborages. Avoid using pegboard, which creates ideal bed bug harborage.

- Clean classrooms every day. Clean hard surfaces with standard cleaning products that are approved for use by the school or childcare policy or state regulations, and vacuum with a HEPA filter. Vacuum floors, desks, chairs, etc., if bed bugs have been observed. Immediately remove the vacuum bag and place it in a sealed trash bag.
- Heat kills all stages of bed bugs and their eggs. Commercial steamers are effective; other heat technologies may be used by pest management professionals. Freezing also kills bugs, and carbon dioxide (CO_2) "snow" may also be used. This method may be used with electronic devices since the CO_2 is nonconductive.

If bed bugs have been found repeatedly in a particular classroom, have the room inspected by a pest management professional or other trained staff. Sticky traps are generally not useful for trapping bed bugs, as they have been shown to avoid the traps. Products designed as interceptors are much more effective and may be placed in corners and as directed. Active traps using pheromone lures may also be effective. Traps using carbon dioxide lures may be very effective in unoccupied rooms (e.g., over a weekend); they are not effective if people are present. These traps may incur rental fees.

Personal Treatments

If a bed bug is found on a student, it **may** indicate that the student has bed bugs at home. Keep in mind that bed bugs may also be introduced by staff or visitors. However, bed bugs can crawl onto or off of any person (or their belongings) at any time, so it is also possible that someone else brought the bed bug to school. If a suspected bed bug is found on a student or a student's belongings, follow this procedure:

- The student should be discretely removed from the classroom so that the IPM coordinator, school nurse, or another qualified individual can examine the student's clothing and other belongings. Any insects found should be removed and collected for identification. Try to keep the specimens as intact as possible for ease of identification (see page 49).
- If possible, several sizes of scrubs, gym clothes, etc., should be kept on hand. This will allow the child to change while their clothes are heat treated in a clothes dryer, if available (30 minutes on high heat in a loosely filled dryer). The student can then change back into their own clothes.
- If a confirmed bed bug was found on a student, then the school principal, childcare director, or nurse should contact the student's parents or guardians to inform them of the bed bug presence on their child. Consider sending a bed bug inspection form home. Educational materials such as those available at **extension.psu.edu/bed-bugs** should also be provided to the family.
- The school principal, nurse, or center program director should consider notifying the affected class(es).
- There is no need to send the student home. Students should **not** be excluded from school due to bed bugs unless repeated efforts have been made to remedy an infestation. Schools should **not** be closed due to bed bug presence. If pest management is necessary, it will normally be targeted to certain areas of the school.
- Generally, pesticides are **not** necessary for bed bug treatment in schools. If an infestation requires the use of pesticides indoors, it **must** be performed by a licensed applicator, overseen by the appropriate school/childcare personnel (such as the IPM coordinator), and conform to Pennsylvania laws (the Pesticide Control Act of 1973, and Act 35 and Act 36 of 2002) and the school's IPM plan.

If a student is dealing with an infestation at home, it is important to be sensitive to the problem. Although bed bugs have nothing to do with cleanliness or socioeconomic status, there is still a stigma that can come with having bed bugs. As a result, parents/guardians may be hesitant to admit to having bed bugs, and students may not want others to know they have an infestation at home. Students living in an infested home may also feel anxious or tired during the school day.

Schools should work with the parents/guardians of any student living in an infested home to develop strategies for preventing the further spread of bed bugs.

- Determine if the infested home is being treated. Home remedies and do-it-yourself treatments are usually insufficient and could cause negative health effects or produce potential hazards in the home.

- Parents/guardians lacking the financial resources to hire a pest management professional can refer to the resources found at **extension.psu.edu/bed-bugs**.
- Heat kills bed bugs at all stages of life, including the eggs; a clothes dryer is a very effective tool against bed bugs. Clothes, bedding, and in fact anything that fits may be heat treated in a clothes dryer, if available (30 minutes on high heat in a loosely filled dryer will kill all bugs and their eggs). If a clothes dryer is not available, ironing clothes thoroughly, especially the seams, will also kill bugs and their eggs.
- Mattresses, upholstered furniture, and cushions can be treated with "dry" steam. It is best to use two professional-grade steamers with low vapor flow rates, each with one-gallon capacities. This allows one unit to always be hot between water refills. The low-pressure steam should exit through a wand with multiple ports to reduce the risk of blowing the bugs out of their hiding places. Using an infrared thermometer, make certain the area just treated is at least 176°F (80°C). Depending on the steam unit used, the wand should pass over the surface of the fabric at about a foot every 10 seconds.
- In an infested home, parents should store their child's freshly laundered clothing in sealed plastic bags or bins until they are put on in the morning. This prevents bed bugs from hiding in the clothing and being carried to school. Other items, such as backpacks and coats, can be inspected daily and stored in sealed containers whenever possible.
- At school, the student should discretely be provided with plastic bags or bins in which to store their belongings in order to prevent any bed bugs from spreading to other students' belongings. Limit the number of items going back and forth from home to school until the infestation is treated. Arrange for nonessential items to be stored at the school if possible.

Chemical Controls

Teachers, coaches, and other staff may **not** have or use aerosol sprays, bug bombs, or other pesticides. Pesticides must be used in accordance with their EPA-approved label directions, including that it is labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and Safety Data Sheets (SDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label. **Pennsylvania law allows pesticide applications in schools and childcares only by certified applicators, registered technicians, or noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must also be posted in an area of common access at least 72 hours prior to and for 48 hours after the application of a pesticide in a school building. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied in a school building where students are expected to be present for normal academic instruction or extracurricular activities.**

Do not apply pesticides until the nonchemical tactics listed above have been used and bed bugs remain in harborages where pesticides are the only viable tool. Use only EPA-registered pesticides labeled for bed bugs and use in schools. Keep in mind that pesticides are poisons and are not usually necessary or recommended for use against bed bugs in schools, especially where individual bed bugs or small populations cannot usually become established infestations.

Two products, Bedlam® (phenothrin with pyrodone) and Sterifab® (phenothrin with isopropanol), are registered for application to mattresses, pet bedding, carpets, and other sensitive areas as allowed by the labeling. However, the PA IPM Program does not recommend using any pesticide on a mattress or other upholstered item in long-term contact with people, ever. Mattresses and box springs should, instead, be contained in special encasements (see **www.bedbugcentral.com** for examples). These prevent any bugs from getting inside the encasement, and trap and starve any bugs inside on the mattress or box spring. The use of encasements eliminates the need for toxic pesticides on an absorbent surface on which children and other people may spend eight hours or more per day, thus reducing pesticide exposure.

Recent research has shown that over 90 percent of bed bugs captured from infestations are resistant to pyrethrins and pyrethroid insecticides, the major category of pesticides available, including Bedlam® and Sterifab®. These insecticides may not inactivate or kill eggs, which will then

hatch and produce nymphs. Additionally, a pesticide approach requires inspection and retreatment 10 to 14 days after the initial treatment. Reliance on pesticides as the sole means of treatment is usually ineffective. Multiple methods of control, especially the nonchemical tactics described above, are essential and have been shown to be more effective than pesticides alone.

Pesticides can be applied to cracks and crevices of dressers, wooden bed frames and headboards, door and window trim, baseboards, and similar sites. Below is information on three classes of insecticides and a newly introduced biopesticide:

1. Botanical insecticides containing natural pyrethrins will repel insects and can "knock down" bed bugs for a period of time, but natural pyrethrins quickly deteriorate and do not provide the necessary residual action of some other materials. Finishes on furniture and other wood items may be damaged from the petroleum carriers contained in aerosol pyrethrins.
2. Inorganic materials such as diatomaceous earth (DE) (food grade, not pool grade!) and silica gel will provide long-term control, provided they are used in an environment with low humidity. Boric acid is not effective against bed bugs because of their biological factors. Silica gels are dusts that are very similar to DE, are often used by professionals, and are very effective. One brand, CimeXa™, is engineered specifically for bed bugs and has been shown to be especially effective. These inorganic materials have very low repellency and a long residual life and can provide good control if properly applied to cracks and crevices. However, these very fine dusts are a respiratory hazard that should be applied only into enclosed voids, such as wall cavities, or electrical switch or receptacle boxes. Gels may leave the surface of items with an undesirable film unless they are carefully applied.
3. Liquid and aerosol products should not be used in schools unless absolutely essential. Synthetic pyrethroids such as deltamethrin, lambda-cyhalothrin, and others can provide control if they are carefully and thoroughly applied to suspected bed bug harborages. However, they do not have residual activity after they are dry. They will not damage materials that are not harmed by water. Recent studies have demonstrated that most wild populations of bed bugs are exhibiting resistance/tolerance to several of the more commonly used synthetic pyrethroid insecticides. However, the microencapsulated materials such as Onslaught® (esfenvalerate) and Demand CS (lambda-cyhalothrin), and a suspended concentrate, Suspend SC (deltamethrin), may offer rapid reduction of susceptible populations. Formulations with two active ingredients have shown better efficacy, including Bedlam Plus, Temprid, Transport, and Tandem. Bed bugs have begun to develop resistance to the neonicotinoid insecticides, which may become ineffective. Bed bugs have not shown resistance to a relatively new material, Phantom® (chlorfenapyr). However, chlorfenapyr may require 10 days to kill the bugs. During this 10-day period, it is important to realize that the bugs may still be active and females may wander and deposit viable eggs in other locations. These products are injected or sprayed into cracks and crevices or bed frames, baseboards, dressers, and drawers, and as spot treatments to carpet along walls. The insect growth regulator (S)-hydroprene (Gentrol®) interferes with the bugs' development but does not render the adults sterile. Another pesticide product sometimes recommended is "No-Pest Strips" (dichlorvos). While effective, it is an organophosphate, which is neurotoxic; the PA IPM Program does not recommend using organophosphates, especially around children. In addition, if used in enclosed spaces, as recommended for bed bugs, the vapors may damage plastics, finishes, and other objects. They are labeled for use only in uninhabited spaces (e.g., attics, garages, and barns).
4. A new option for bed bug control entered the market in November 2017. Aprehend® is an EPA-registered biopesticide that was developed at Penn State. It is composed of *Beauveria bassiana* spores in a solution and applied using an ultra-low-volume sprayer. *Beauveria* has been widely used in agriculture; this is the first time it has been used for indoor application, and it has been thoroughly tested for human safety. Two-inch-wide barrier applications are made over baseboards and other probable bed bug harborage areas. It is not necessary to spray the bugs or their harborages directly; when the bed bugs crawl across the dried barrier, the spores are picked up by the bugs, which then distribute them among the colony. Laboratory testing shows that individual bugs die in about four days, and the colony in

about 10 days. It has residual activity for up to three months. Application involves novel techniques and must be done by a trained, licensed applicator only. More information is available at **www.aprehend.com**.

For infestations other than the common bed bug (*C. lectularius*), a bird or bat that has occupied the structure should be removed by a Nuisance Wildlife Control Operator, and measures taken to prevent the reentry of these and other animals. If you have any questions or concerns about wildlife and its removal, contact the Pennsylvania Game Commission at 717-783-6527. The materials and tactics listed for the common bed bug will also control other bug species, provided that treatment considerations be given to the potential harborages (e.g., crevices between rafters, cracks in chimney flues) that will differ from the common bed bug.

EARLY DETECTION

Prevention is the gold standard of IPM, but bed bugs' unique characteristics make prevention difficult. Early detection and treatment is essential to prevent an introduction from becoming an infestation. Removing clutter from classrooms and minimizing materials moving between school and other locations reduce the opportunity for bed bugs to invade and colonize. Careful inspection of incoming materials and people is recommended. See and apply the nonchemical treatments provided above.

- Review or create a policy on bed bugs.
- Contract with a pest management professional committed to an IPM response to bed bugs.
- Create protocols for response.
- Communicate these to all staff, including teachers and facilities employees.
- Communicate the policies and procedures to parents at the start of each school year.
- Emphasize the importance of immediate reporting.
- Inspect immediately if bed bugs are observed or suspected.
- If bed bugs are confirmed, have the contracted pest management professional conduct appropriate treatment immediately; use nonchemical methods first.
- Notify parents immediately.
- Do not use aerosols or foggers. Use liquid or spray pesticides only when essential. Dusts and gels are preferred.
- Use interceptors or monitors (e.g., Climb-ups™ or Volcanoes™) in vulnerable areas like waiting areas, the nurse's office, and so forth.
- Monitor and evaluate the effectiveness of the response and the treatment; revise policies and protocols if necessary.

Preparation, protocols, and proactive communication are essential!

Sample Bed Bug Policy and Action Plan

Goal: _____ [Name of your school/childcare/organization] is committed to providing a safe, pest-free environment for the children in our care, our staff, and visiting parents/guardians.

We follow an integrated pest management approach to all pests. This means our emphasis is on **P**REVENTION of pests first; **E**LIMINATION by multiple, least toxic methods if needed; **A**SSESSMENT of success; **C**OMMUNICATION within the organization and the community we serve; and **E**DUCATION about everyone's role in safely keeping all pests out.

Purpose: Implement Effective and Safe Policies and Procedures for Bed Bugs

Bed bug prevention and elimination require extra attention than most pests. Bed bugs can accidentally be transported to and from home/work/school on people's belongings. Thus, prevention and elimination require everyone to be aware and involved for best results.

P-E-A-C-E Approach

Prevention

Our goal is to be proactive and prevent bed bugs from entering our facilities. We will:

- Inform staff, parents, and others of ways to reduce bed bug transmission.
- Establish routine inspections in places where bed bugs might hide.
- Prioritize facility improvements to reduce conditions for bed bugs to hide.
- Pre-establish a method of isolating personal belongings.
- Pre-establish nonchemical methods (e.g., heat, steam) for treating belongings.
- Establish roles and responsibilities for these activities.

Elimination

Our goal is to eliminate bed bugs in the safest, most effective ways possible. If bed bugs are discovered we will put our action plan into place, depending on the situation. **Introductions** are not treated the same as **infestations**.

An **introduction** is few bugs brought in on belongings. They have not established themselves in the room/building. Staff will be trained to handle bed bug introductions in the manner described below.

An **infestation** is an actively breeding resident population, which is extremely uncommon in center-based and school facilities, but possible in infant rooms and home-based facilities. Infestations will require the help of a licensed pest control professional.

We will:

- Try to identify how bed bugs are being introduced into the facility (child? staff? visitor?).
- Work in collaboration with a bed bug qualified, licensed pest control professional.

If bed bugs are found on a child's belongings, we will:

- Discretely engage the child and examine belongings away from the classroom.
- If bed bugs are confirmed, immediately contact parents by phone.
- Heat treat belongings on site if possible; if not possible, isolate belongings.
- Arrange for parents' cooperation in sending an extra set of clothing to school.
- After students have left, thoroughly inspect classroom and follow protocol below.

- Engage parents in education and discussion of how to deal with home infestation.

If bed bugs are suspected in the classroom/office environment, we will:

- Inspect and positively identify bed bugs and their location.

If none found, remain vigilant; if yes, continue:

- Bag, remove, and heat treat belongings in the immediate area where bed bugs were found.
- Notify parents and staff that bed bugs were found and what their role is to help.
- Implement protocol to isolate all personal belongings brought into the classroom.
- Determine level of treatment needed based on number/location of bed bugs (e.g., a small introduction of one or two bed bugs in an isolated area may only require thorough vacuuming, clutter reduction. and isolation of belongings).

Assessment

Our goal is to assess whether our prevention and/or treatment efforts have successfully eliminated bed bugs from the facility. We will:

- Reinspect classrooms weekly after treatments to check for bed bugs for two weeks.
- Establish a nighttime monitoring system with passive or active traps for two weeks.

Communication

Our goal is to ensure everyone in our community understands our school/childcare Bed Bug Policy and Action Plan. Understanding the challenges we all face with bed bugs and good communication are essential to gaining cooperation and control.

We will:

- Integrate all pest management policies and action plans into the existing Environmental Health and Safety Plan of our school/center.
- Delegate a person in charge of oversight and communication on all pest management issues, including bed bugs.
- Establish “pathways” for communicating to staff and parents during a pest “crisis.”
- Communicate closely with our licensed pest management professional in a team effort.

Education

Our goal is to ensure everyone fully understands the facts about bed bugs and safe and effective treatments to prevent and eliminate them from schools/childcares and homes.

We will:

- Establish a regular schedule to educate staff, parents, custodians, and facilities managers on **all** pests and bed bug basics.
- Assist parents/guardians in communicating with landlords on bed bug issues.

1. Who will be your point person/decision-maker for pests and bed bug issues arising in your facility?
2. Who in the school community needs to be involved?
3. Who outside the school community needs to be involved?
4. How will you make sure your bed bug policy and action plan is followed?

IPM for Clothes Moths and Carpet Beetles

INTRODUCTION

The insects discussed in this chapter, clothes moths and carpet beetles, are sometimes referred to as fabric pests. They feed on wool, feathers, fur, hair, leather, lint, dust, paper, and occasionally cotton, linen, silk, and synthetic fibers. Most damage is done to articles left undisturbed for a long time, such as surplus art and craft materials in storage closets.

IDENTIFICATION AND BIOLOGY

Clothes Moths

The most common fabric-attacking moths are the webbing and the casemaking clothes moths. Both the webbing clothes moth *(Tineola bisselliella)* and the casemaking moth *(Tinea pellionella)* are common in Pennsylvania. The adults of both species are about ¼ inch long and have a wingspan of about ½ inch. The webbing clothes moth is golden buff or yellowish gray with a satiny sheen, and the hairs on its head are upright and reddish. The casemaking clothes moth is similar in size and shape but has a browner hue and three indistinct dark spots (which may be worn off with age) on the wings, with lighter-colored hairs on the head.

Adult moths of both species avoid light and attempt to hide when disturbed, which helps distinguish these moths from other small moths found in buildings **(TABLE 3.1)**. Clothes moths are occasionally seen flying in subdued light. Males fly more often than females, but both may fly considerable distances and can move from building to building in favorable weather. Adults can be seen flying at any time of year, but they are more common during the summer months.

The life cycles of the two moths are similar. Adult females lay an average of 40 to 50 eggs. Incubation takes from four days to three weeks or sometimes longer. If conditions are good—meaning abundant food, temperatures around 75°F, and at least 75 percent relative humidity—a new

Table 3.1. Distinguishing Between Common Clothes Moths and Grain Moths

SPECIES	DISTINGUISHING CHARACTERISTICS
Angoumois Grain Moth (*Sitotroga cerealella*), **FIGURE 3.1A**	Wingspan ⅝ inch; pale yellow forewings and gray pointed hind wings
Casemaking Clothes Moth (*Tinea pellionella*), **FIGURE 3.1B**	Slightly smaller than webbing clothes moth; whitish head; wings black on first third, lower two-thirds creamy white, may have some spots on white area; larvae always in case; adults fly in dark areas
Indian Meal Moth (*Plodia interpunctella*), **FIGURE 3.1C**	Wingspan ⅝ inch, ⅜ inch at rest; wings light gray at base with reddish-brown or bronze on outer half; favors dried fruit but will feed on many other stored products
Mediterranean Flour Moth (*Anagasta kuehniella*), **FIGURE 3.1D**	Wingspan ⅘ inch; hind wings dirty white, forewings pale gray with transverse black wavy bars; forebody distinctly raised at rest
Webbing Clothes Moth (*Tineola bisselliella*), **FIGURE 3.1E**	Wingspan ½ inch, body length ¼ inch; wings golden yellow without spots, hind wings rounded; body covered with shiny golden scales; tuft of reddish hairs on head

Adapted from Olkowski et al. (1991).

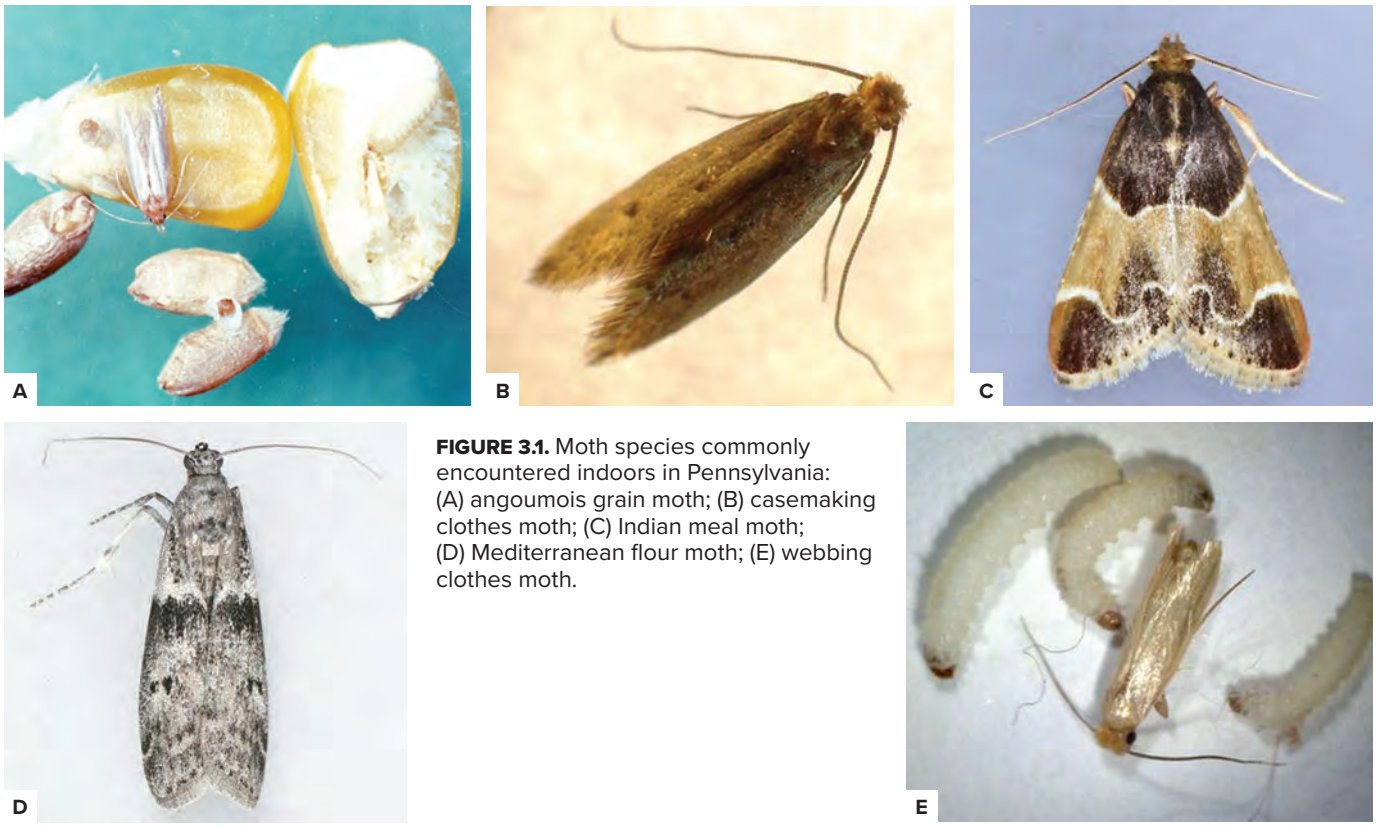


FIGURE 3.1. Moth species commonly encountered indoors in Pennsylvania: (A) angoumois grain moth; (B) casemaking clothes moth; (C) Indian meal moth; (D) Mediterranean flour moth; (E) webbing clothes moth.

(A) CLEMSON UNIVERSITY–USDA COOPERATIVE EXTENSION SLIDE SERIES, BUGWOOD.ORG; (B, E) MOHAMMED EL DAMIR, BUGWOOD.ORG; (C, D) MARK DREILING, BUGWOOD.ORG

generation can be produced in a month. It takes over a year when conditions are less favorable, and periods up to four years have been recorded in the laboratory. The larval and pupal stages combined may take from 45 days to more than a year to complete. At ordinary household temperatures, adult moths live from two to four weeks. The adults do not feed on fabrics.

In heated buildings, female webbing clothes moths can mate and lay eggs anytime during the year. The casemaking clothes moth generally produces one generation each year.

The larvae of both moths are also similar (pearly white, naked bodies and dark heads), but the casemaking moth larva spins a characteristic silken tube under which it feeds. These tubes can include parts of the fabric. Larvae of both species range from ¼ to ½ inch long when fully grown. Their fecal matter is often the same color as the material they consume.

Carpet and Hide Beetles

Adult beetles are small and have short, clubbed antennae, but are otherwise varied in appearance **(TABLE 3.2)**. Their bodies are covered with small scales or hairs, which are visible with a magnifying glass. Larvae are brownish, ⅛ to ½ inch long, and characteristically hairy or bristly.

Table 3.2. Important Carpet or Hide Beetles and Their Food Sources

SPECIES	DESCRIPTION OF ADULTS	FOOD SOURCE
Black Carpet Beetle (*Attagenus unicolor*), **FIGURE 3.2A**	1/10 to 1/5 inch long; oval; shiny black and dark brown with brownish legs	Feathers, dead birds, birds' nests, seeds, grains, cereals, woolen rugs, clothing, carpeting, felts, furs, skins, yarn, velvet, silk, upholstered furniture, milk powder, books, pet food, spilled flour, pollen
Black Larder Beetle (*Dermestes ater*), **FIGURE 3.2B**	3/10 to 2/5 inch long; black with yellowish gray hair; black, rounded and hook-shaped spots on underside of abdomen	Mouse carcasses in walls of building, partially burned food and other kitchen wastes in incinerators, pet food
Common Carpet Beetle (*Anthrenus scrophulariae*), **FIGURE 3.2C**	1/8 inch long; blackish with varied pattern of white and orange scales on back; scalloped band of orange-red scales down middle of back	Carpets, fabrics, woolens, feathers, leather, furs, hairbrush bristles, silks, mounted museum specimens; adults found on blossoms; can enter buildings on cut flowers
Furniture Carpet Beetle (*Anthrenus flavipes*), **FIGURE 3.2D**	1/10 to 1/5 inch long; definite cleft at rear; mottled with black, white, and yellow scales	Wool, hair, fur, feathers, bristles, horn, silk, animal excreta, stained linen, cotton, rayon, jute, softwood, leather, bags, dead mice, dead insects, dried cheese, old grain, casein, dried blood, and glue of book bindings
Hide Beetle, Leather Beetle (*Dermestes maculatus*), **FIGURE 3.2E**	1/5 to 2/5 inch long; black with white hairs on sides and undersides; apex of each wing cover comes to a fine point	Prefers hides and skins; used to clean carcasses; known to survive on smoked meat and dried cheese; larvae can tunnel short distances into wood
Larder Beetle (*Dermestes lardarius*), **FIGURE 3.2F**	3/10 to 2/5 inch long; dark brown with pale grayish yellow hair; yellow band at base of wing covers with about six black spots	Stored ham, bacon, meats, cheese, dried museum specimens, dried fish, dog biscuits; can tunnel slightly in wood; reported to attack newly hatched chickens and ducklings
Varied Carpet Beetle (*Anthrenus verbasci*), **FIGURE 3.2G**	1/8 inch long; mottled with white, brownish, and yellowish scales	Nests of bees, wasps, and spiders; carpets, woolen goods, skins, furs, stuffed animals, leather book bindings, feathers, horns, hair, silk, corn, red pepper, dead insects in collections
Warehouse Beetle (*Trogoderma variabile*), **FIGURE 3.2H**	1/8 inch long; brownish black	Prefers barley, wheat, animal feeds, grains, pollen; found in seeds, dead animals, cereals, candy, cocoa, cookies, corn, corn meal, dog food, fish meal, flour, dead insects, milk powder, nut meats, dried peas, potato chips, noodles, dried spices

Adapted from Mallis (1997) and Olkowski et al. (1991).

As with clothes moths, the larval stage is the most damaging **(FIGURE 3.3)**. Females lay eggs throughout the year and the eggs hatch in less than two weeks. The larvae feed for varying periods, depending on the species and environmental conditions. When ready to pupate, the larvae may burrow farther into the food or wander and burrow elsewhere. They also may pupate within their last larval skin or burrow into wood if no other location is found. Beetle larvae do not construct webs, but their shed skins and fecal pellets make it obvious where they have been feeding. The cast skins look so much like live larvae that under casual inspection they may seem to indicate a far larger infestation than is actually present.

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FIGURE 3.3. Clothes moth larva.

Some adult carpet beetle species feed on pollen and nectar; they may be introduced into a school on cut flowers. They are sometimes mistaken for lady beetles because some species are similarly round in shape.

DAMAGE

Clothes Moths

Adult clothes moths do not feed; only their larvae cause damage. Clothes moth larvae feed on pollen, hair, feathers, wool, fur, dead insects, and dried animal remains. Feeding holes are usually small and scattered over the material. Clothing, carpets, furs, blankets, upholstery, piano felts, and myriad other items are subject to their attack. They will also feed on wool mixed with synthetic fibers. Only the wool is digested; the other fibers pass through the insect's gut. Clothes moths are attracted to stains on fabrics from food and human sweat and urine. Clothes moths most often damage stored goods because the larvae are fragile and cannot survive in clothing worn regularly.

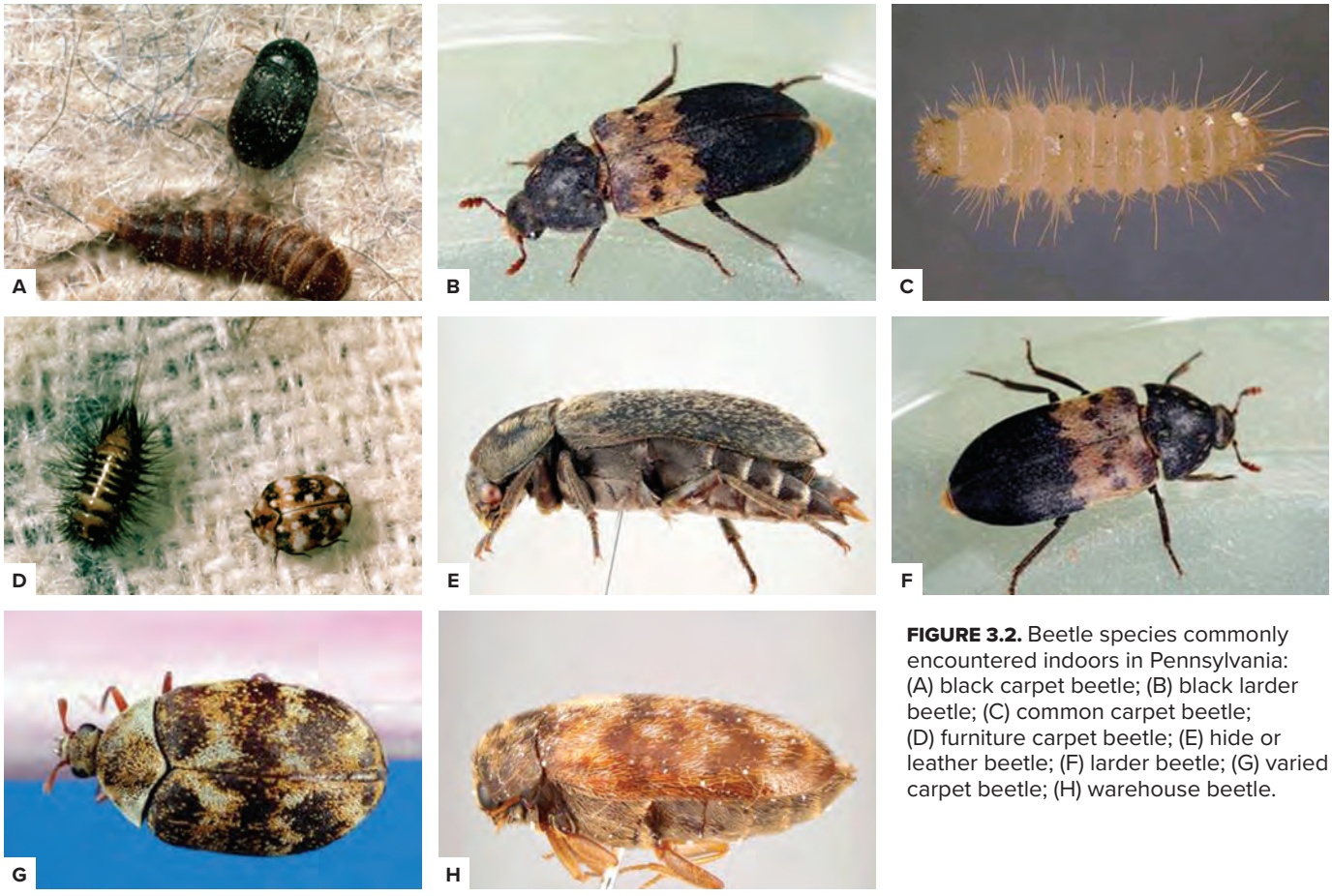

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FIGURE 3.2. Beetle species commonly encountered indoors in Pennsylvania: (A) black carpet beetle; (B) black larder beetle; (C) common carpet beetle; (D) furniture carpet beetle; (E) hide or leather beetle; (F) larder beetle; (G) varied carpet beetle; (H) warehouse beetle.

Carpet and Hide Beetles

Carpet beetle holes are usually concentrated in a few areas and can be quite large, in contrast to clothes moth holes. As a group, these beetles cause far more damage than clothes moths since the range of substances they consume is much wider. Carpet beetles damage materials made from wool, such as sweaters, uniforms, felt, and wool yarn. They can also destroy insect collections, furniture, and carpets. Hide beetles feed on animal carcasses and hides, and also damage furnishings, carpets, and fabrics. Some species also infest stored dried foods, such as cereal (see Table 3.2).

DETECTION AND MONITORING

Look for holes in fabric, larvae, moth cocoons, cast skins of beetle larvae, or insect excreta in stored materials or small moths fluttering about in dimly lit areas. The fluttering flight itself is quite distinctive and may be enough to distinguish clothes moths from food-infesting moths, which have a steadier flight.

Unlike moth larvae, carpet beetle larvae may be found wandering far from their food, particularly to pupate. They will sometimes burrow into wood, Styrofoam, and other objects in order to pupate. Also, unlike clothes moths, adult carpet beetles do not shun light and may be found crawling on windows. This is often the first place they are noticed.

These beetles and moths are easy to catch: cover the insect with a jar and slowly slide a card under the open end. Seal the jar and place it in the freezer overnight. The dead insect can be examined with a magnifying glass or taken to your Penn State Extension educator or another professional for identification.

An inspection should include the following locations:

- Around carpets or furniture covered or filled with susceptible materials; infestations may be under the slipcovers, where it is dark and quiet, or in the pads under the carpet
- Around accumulations of lint and other organic debris, particularly under and behind furniture that is rarely moved; in wall and floor cracks; in cracks behind filing cabinets, shelves, or other built-in items that may not be flush with the wall; behind baseboards, moldings, and window trim; and in cold air and heater ducts

- Around stored animal specimens, feathers, garments, blankets, or other items made of susceptible materials
- Around bags or boxes of dried milk, fish or meat meal, dog food, and similar products (note that carpet beetles can bore through cardboard and paper packaging)

If the infestation does not appear to be large enough to account for the number of pests found or cleaning up the infestation does not seem to diminish their numbers, then a further search should focus on less obvious sources:

- Bird, wasp, bee, squirrel, or other animal nests on or very close to the walls of the building
- Animal carcasses or trophies, insect collections, or leather or horn goods
- Cut flowers or blooming bushes near open, unscreened windows or doorways
- Incompletely incinerated garbage

In some circumstances, sticky traps placed in areas where activity is suspected may be useful for monitoring. Hang them where you suspect there might be an infestation and check them daily. Sticky traps that contain an attractant called a "sex pheromone" (a chemical signal that female moths give off to attract males) are available to monitor for the webbing clothes moth.

MANAGEMENT OPTIONS

Physical Controls

Storage in Tight Containers

If clean materials are placed in tightly sealed containers, they will be safe from infestation. The problem with closets and similar storage areas is that they are almost impossible to seal effectively since the tiny, newly hatched larvae can crawl through any gap larger than 0.0004 inch.

Wrap clean susceptible materials in heavy brown paper and carefully seal the package with heavy-duty tape. As long as the package is not punctured or torn, the contents should be safe from attack for years. Clean materials could also be stored in heavy-duty resealable plastic bags or heavy-duty plastic garbage bags (2.7 mils or thicker or use a double bag) sealed with tape. All grains, cereals, and other similar susceptible substances should be stored in tight-fitting containers that deny beetles access. Containers can be placed in the freezer for a few days to help reduce the possibility of an infestation developing.

Cedar Products

Cedar chests have long been thought to protect against fabric pests, but it has been known for many years that although cedar oil can kill very young clothes moth larvae, the oil does not affect eggs, pupae, adults, or larger larvae, and cedar lumber loses its oil in only a few years. Moreover, commercial repellents made from cedar, cedar oil, or herbs cannot be counted on to give adequate control to protect goods.

Vacuuming

Accumulations of lint, human and animal hair, and other organic debris in cracks and crevices of floors, baseboards, closets, and shelves provide food for fabric pests. These areas should be cleaned thoroughly and regularly to prevent infestations. It is particularly important to clean under furniture that is rarely moved (e.g., desks, bookcases, cabinets); in closets where fabric items, furs, and feather-filled materials are stored; and inside and behind heaters, vents, and ducts.

Caulking

Caulking or otherwise repairing cracks and crevices where lint and hair can accumulate will reduce the number of fabric pests that are able to live in the environment. Areas of particular concern are the spaces inside cabinets where shelves do not meet the wall and similar spaces in drawers holding susceptible materials. These same habitats are likely to be inviting to cockroaches, which can also damage stored products.

Cleaning and Airing Fabrics, Carpets, and Furniture

Since many fabric pests are attracted to food, beverage, perspiration, and urine stains in woolens and other materials, garments should be cleaned thoroughly before being stored. If materials cannot be stored in moth- and beetle-proof packages or containers, they should be shaken, brushed, and aired regularly. This will kill delicate moth larvae and cocoons. Vigorous brushing can remove moth and beetle eggs. Susceptible furniture and carpets that cannot be washed should be steam-cleaned. Fabrics and other items badly damaged by beetles should be thrown away in sealed plastic bags or burned. If the item is salvageable, submerge it in hot, soapy water (at least 120°F) for two to four hours to kill the larvae and eggs.

Exposure to Heat

Heat can be used to kill all stages of the clothes moth hiding in cracks and crevices of an infested closet or storage space. Remove all materials from the space and place a heater in the center of the

floor. Turn the heater to its hottest setting and monitor the temperature with a thermometer that registers temperatures over 120°F. Keep the temperature at 130 to 140°F for one to four hours to kill the insects. Make sure there are no materials in the area that can be damaged by sustained heating. This kind of heating may not be used if fire-suppression sprinklers are present (see the discussion of heat treatments in the bed bugs section on page 50 for more information).

Removal of Animal Nests

Clothes moths and carpet beetles can sometimes move into buildings from abandoned nests of birds, rodents, bats, bees, and wasps and the carcasses of dead animals. Remove nests in the eaves or close to the walls of the school. Problems with birds' nests usually occur after the nestlings have left. Nests should be removed before the cold weather sets in and the beetles begin searching for sheltered hibernation spots. Use traps instead of rodenticide to resolve problems with rats and mice. If rodents die in inaccessible places, their carcasses can become food sources for fabric pests and flies.

Chemical Controls

Crack and Crevice Treatments

In older wooden buildings, these pests may be found throughout the structure hiding in crevices that protect them from treatment. Use a silica aerogel or diatomaceous earth as a dust in cracks and crevices and voids. An insect growth regulator (IGR) may be needed in some cases. Pesticides must be used in accordance with their EPA-approved label directions, including that it is labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and Safety Data Sheets (SDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label. **Pennsylvania law allows pesticide applications in schools only by certified applicators, registered technicians, or noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must also be posted in an area of common access at least 72 hours prior to and for 48 hours after the application of a pesticide in a school building. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied in a school building where students are expected to be present for normal academic instruction or extracurricular activities.**

IPM for Cockroaches

INTRODUCTION

Cockroaches are the most important pests within schools, homes, and restaurants. They consume human foods and contaminate them with saliva and excrement. They produce secretions that impart a characteristic fetid odor. Their feces and shed skin contain allergens that can cause or trigger allergic reactions, such as an asthma attack and other bronchial problems, in people inhabiting or visiting infested buildings.

IDENTIFICATION AND BIOLOGY

Except for size and markings, cockroaches are generally similar in appearance: all species are flattened, oval-shaped insects with long legs and antennae. Only four species are common pests in Pennsylvania: German, brown-banded, American, and Oriental cockroaches. The Pennsylvania wood cockroach is an occasional invader in wooded areas, but it dies shortly after entering a building and is therefore not considered a pest. **TABLE 4.1** lists their important characteristics. Two other species, the Cuban and Surinam cockroaches, have been found in greenhouses and malls in Pennsylvania. They have not been included in the key.

In general, cockroaches like to squeeze into warm cracks and crevices, but the places they inhabit differ from one species to another. German cockroaches prefer kitchens and lavatory areas, while brown-banded cockroaches are most often found in dryer classroom and office areas. American and Oriental cockroaches are generally

Table 4.1. Characteristics of Common Cockroach Species

SPECIES	COLOR AND DISTINCTIVE MARKINGS	LENGTH OF ADULT	AVERAGE NUMBER OF EGGS PER EGG CASE*	LIFE CYCLE FROM EGG TO ADULT
American Cockroach (*Periplaneta americana*), **FIGURE 4.1A**	Reddish brown throughout with a pale band on the edge of the pronotum (platelike structure behind the head on the back)	1½–1¾ inches	14	320–1,071 days
Brown-Banded Cockroach (*Supella longipalpa*), **FIGURE 4.1B**	Tan with faint, V-shaped, lighter bands on wings; nymph has two distinct brown bands running crosswise on body	⅜–½ inch	16	143–379 days
Cuban Cockroach (*Panchlora nivea*), **FIGURE 4.1C**	Uniformly pale green; both sexes fully winged; good fliers	⅞–1 inch	56	144–181 days
German Cockroach (*Blattella germanica*), **FIGURE 4.1D**	Light brown with two black bars on the pronotum	½–⅝ inch	37	64–251 days
Oriental Cockroach (*Blatta orientalis*), **FIGURE 4.1E**	Dark brown-black throughout; adult male wings do not cover abdomen; adult females are wingless	1¼ inches	18	316–533 days
Pennsylvania Wood Cockroach (*Parcoblatta pensylvanica*), **FIGURE 4.1F**	Males are chestnut brown, females are black; adult male wings cover the abdomen; adult females have short, nonfunctional wings	⅝–1 inch	26	324–700 days
Surinam Cockroach (*Pycnoscelus surinamensis*), **FIGURE 4.1G**	Pronotum uniformly dark; dark olive-green wings that extend beyond abdomen; no known males exist (parthenogenetic species)	¾ to 1 inch	26	162–219 days

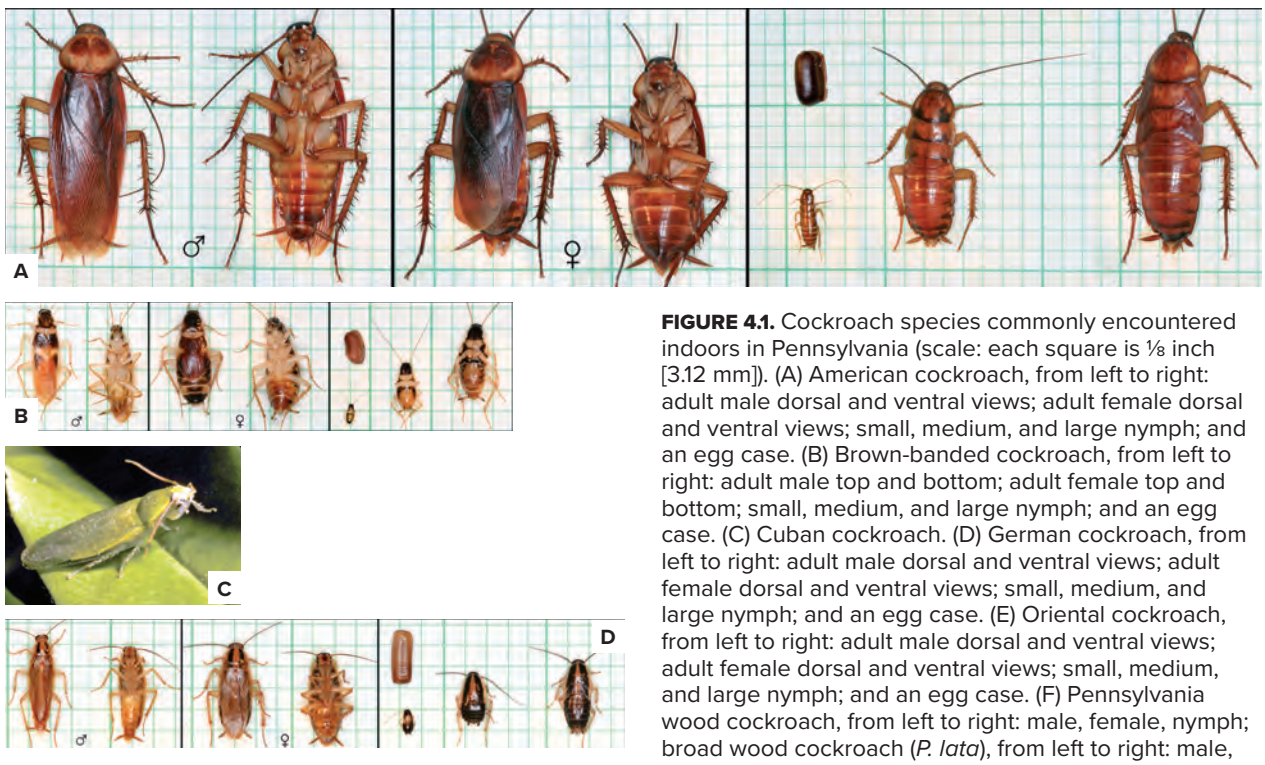
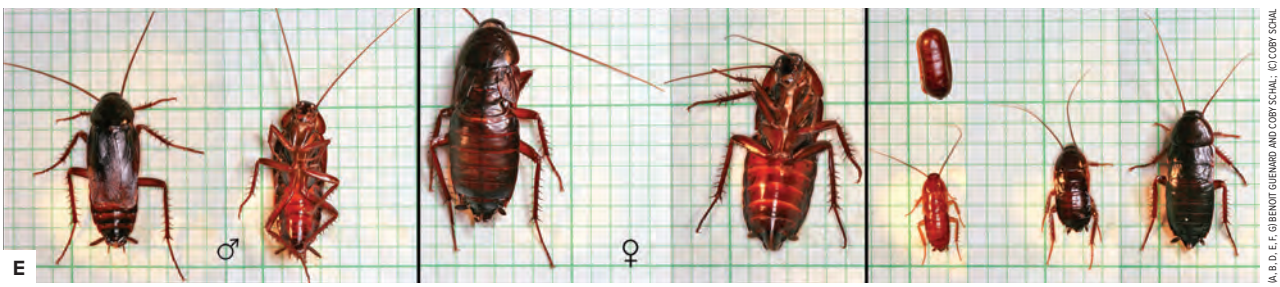


FIGURE 4.1. Cockroach species commonly encountered indoors in Pennsylvania (scale: each square is ⅛ inch [3.12 mm]). (A) American cockroach, from left to right: adult male dorsal and ventral views; adult female dorsal and ventral views; small, medium, and large nymph; and an egg case. (B) Brown-banded cockroach, from left to right: adult male top and bottom; adult female top and bottom; small, medium, and large nymph; and an egg case. (C) Cuban cockroach. (D) German cockroach, from left to right: adult male dorsal and ventral views; adult female dorsal and ventral views; small, medium, and large nymph; and an egg case. (E) Oriental cockroach, from left to right: adult male dorsal and ventral views; adult female dorsal and ventral views; small, medium, and large nymph; and an egg case. (F) Pennsylvania wood cockroach, from left to right: male, female, nymph; broad wood cockroach (*P. lata*), from left to right: male, female, nymph. (G) Surinam cockroach, from left to right: adult female top and bottom; small, medium, and large nymph; and an egg case, which is incubated within the female.

REPRODUCTION CHARACTERISTICS	PREFERRED HABITAT
Egg case deposited on or near floor, usually close to food and concealed in debris; needs high humidity to hatch	Usually found in basements or sewers; can live outside during warm weather; prefers warm, moist areas, such as around furnaces or heating ducts, steam pipe tunnels, drainage manholes and grease traps, and sewers
Egg case glued to ceilings, beneath furniture, or in closets; will glue egg cases on top of one another	Favors cracks and crevices but prefers them in warm, dry areas throughout the building; prefers high locations in heated buildings but can also be found under furniture, in appliances that generate heat, including computers, etc.; on the undersides of counters that support appliances that generate heat; in ceiling light fixtures, telephones, desks, boxes, and piles of debris or stored material in closets; and behind pictures and picture frames
Female carries egg case until the nymphs hatch	Tropical insect; found only in greenhouses, malls, and indoor plantings; attracted to lights; active at night
Female carries egg case until the nymphs hatch	Usually found in kitchens and restrooms; prefers dark voids such as cracks and crevices not more than 3/16 inch wide, especially in warm, moist areas, such as food preparation areas; the undersides of tables, kitchen equipment, and service counters; kitchen cupboards; motor compartments of refrigerators; electrical fuse boxes; and spaces under broken plaster or behind sinks; are also attracted to classrooms where food is eaten
Secures and conceals egg case in crevice; usually covers egg case with debris or sometimes with fecal pellets	Found in areas with excessive moisture; cooler areas of a building, such as basements, service ducts, and crawl spaces; can also tolerate hot, dry locations such as radiators, ovens, and hot water pipes, as well as colder temperatures; is capable of overwintering outdoors in colder regions of the United States
Egg case deposited only during summer, in wooded area	Found in wooded areas; males attracted to lights; occasional invader in rural areas; usually lives outside in hollow trees, under loose bark, and often in wood piles and crevices in rural buildings; nymphs can be active in subzero weather when exposed by pulling away bark from trees; adults present from May through early October
Female carries egg case until the nymphs hatch	Tropical insect; found only in greenhouses, malls, and indoor plantings; burrows into loose soil



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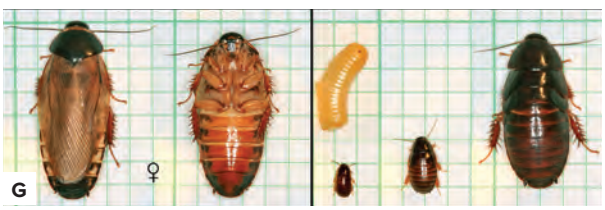

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(A, B, D, E, F, G) BENOIT GUENARD AND COBY SCHAL; (C) COBY SCHAL

found where there is high moisture, such as in sewers, basements, and mulch. Pennsylvania wood cockroaches are usually found only in wooded areas. They occasionally invade rural schools. The Cuban and Surinam cockroaches have only been found in indoor plantings, where they may damage the plants.

The life cycle of the cockroach begins with the egg case, or ootheca. In German, Cuban, and Surinam cockroaches, the female transports the egg case around with her until the eggs are about to hatch. The brown-banded, American, and Oriental cockroaches deposit the egg case in a sheltered place, and the Pennsylvania cockroach deposits the egg case in wooded areas (see Table 4.1). Cockroaches undergo a gradual metamorphosis during their life. An immature cockroach, or nymph, looks much like an adult but smaller and wingless. As a nymph grows, it sheds its skin (molts) a number of times. The time it takes a cockroach to become an adult is affected by temperature. For example, cockroach nymphs develop more rapidly when it is warm.

Cockroaches eat carbohydrates, protein, and fat. They will discriminate among foods if given a choice, but when hungry they eat almost anything. Some products not normally considered food (e.g., starch-based paints, wallpaper paste, envelope glue, and bar soaps) contain carbohydrates and are therefore food for cockroaches.

Cockroaches are generally active at night and remain hidden during daylight. Daylight sightings usually indicate a large population that has overrun available harborage or a recent emigrant cockroach seeking shelter.

DAMAGE

Cockroaches can carry and transmit many common pathogens that cause human and animal disease. Consequently, their presence in kitchens and cafeterias should be deemed hazardous to health. However, the most important health issue associated with cockroaches is the production of allergens that can trigger asthma and other respiratory problems in sensitive individuals, most notably in children and the elderly (see “Asthma, Pests, and Pesticides” on page 32 for more information).

DETECTION AND MONITORING

Efforts to manage cockroaches should begin with a thorough visual inspection and a continuous monitoring program. Once cockroaches have located a suitable harborage, they tend to concentrate in that site, which they leave only periodically to forage for food and water. Thus, the first step in any inspection is to locate potential cockroach harborage sites. This effort should be followed by monitoring of the area to locate specific cockroach infestations. This monitoring must continue after treatment to determine whether management efforts have satisfactorily reduced the cockroach population.

Establishing a Communication System

A successful monitoring program depends on clear and frequent communication with principals, teachers, custodians, and food service personnel. These people have firsthand knowledge of pest sightings, sanitation problems, and other contributing factors, such as leaks, condensation problems, and harborage sites. With a small investment of time, school personnel can be trained to serve as additional sources of valuable information for the monitoring program. Make sure personnel understand the following:

- The goals of the cockroach IPM program and the role monitoring plays
- Their role in the IPM program (what they can do to help reduce the number of cockroaches and what kind of information they can provide)
- How they can best communicate with the pest management technicians (using log sheets to write down pest sightings and other information)

Visual Inspection

- Note any sanitation problems, such as food or grease spills, food or grease buildup behind or under kitchen equipment, or improper garbage disposal procedures.
- Note any leaks or condensation.
- Look for cockroach entry points, such as holes in walls or floors, around pipes where they may enter a wall, around electrical conduits, or in vents.
- Use the list of preferred habitats in Table 4.1 to help you decide where to inspect, and refer to the list of tools used to inspect and monitor for cockroaches on the next page.
- Record on a “Pest Sighting Chart” locations where cockroaches have been found for repeat monitoring.

Where to Inspect

Define the specific areas on a map that are to be inspected for cockroaches. Inspect these areas from floor to ceiling in a systematic and logical fashion, making sure no potential harborage areas are overlooked. Be sure to inspect:

- Corners of rooms at floor and ceiling level
- Under, behind, and around sinks, toilets, showers, bathtubs, drinking fountains, ice machines, dishwashers, beverage dispensers, and floor drains
- Engine compartments of refrigerators, beverage dispensers, toasters, air conditioners, and other equipment
- In and under stoves, hot plates, heaters, and near hot water pipes and radiators and radiator covers and other equipment and supply chases
- In and around stove vents, hoods, and grease traps
- Between equipment and walls, and between adjacent appliances
- Behind picture frames, mirrors, bulletin boards, and wall-mounted shelving
- False ceilings, vents, light fixtures, ceiling-mounted fixtures, and railings
- Cupboards, linen closets, drawers, filing cabinets, lockers, and cluttered areas
- In and under cash registers, computers, telephones, electric clocks, televisions, switch boxes, and fuse boxes
- In and around checkout stands, vegetable bins, and meat counters
- Cracks and crevices in walls and baseboards
- Under edges and in corners of tables, desks, counters, and other furnishings and equipment
- Indoor and outdoor trash containers, dumpsters, and recycling containers
- Loading docks and storage areas where incoming food, supplies, equipment, and other potential sources of migrating cockroaches are received and stored

When to Inspect

Most inspections are conducted during daylight hours for the convenience of the inspector.

Tools Used to Inspect and Monitor for Cockroaches

Flashlight. Use a heavy-duty, corrosion-resistant model with a bright-colored body, shatterproof lens, and LED bulbs. A smaller LED or halogen flashlight with a flexible neck is useful in tight, confined locations. Flashlight holders that can be attached to a belt are available. Headlamps are also invaluable inspection tools. Carry spare batteries, especially for high-power lamps.

Digital camera. A small digital camera is useful for illustrating specific conditions (such as unsanitary situations or areas needing pest-proofing) in reports to decision makers or subcontractors not on the premises. It can be slipped into small spaces to document what is inside. Digital cameras date and time-stamp images. Start photo sequences with the building name or each room number to identify locations. Carry extra batteries and SD cards (or other digital storage medium).

Telescoping mirror. Use a furnace inspector's or mechanic's metal mirror with a telescoping handle and rotating head. To illuminate areas inside equipment and fixtures, reflect the flashlight beam off the mirror.

Clipboard and pen. Use the clipboard to carry monitoring forms, floor plans, and other documents during inspections.

Floor plan maps and building plans. Carry a floor plan with the major equipment and fixtures marked. A fire evacuation base map is usually used. In large buildings, construction drawings that show utility lines, heating/cooling ducts, shaft connections, pipe chases, and other features are very useful for locating entry points, harborages, and runways.

Sticky traps. These are used to locate harborage areas and estimate populations.

Flushing agent. A pocket-sized can of pressurized air is useful for spot-flushing roaches out of inaccessible areas where trapping is not sufficient.

Utility tools. A pocketknife or multitool equipped with various blades, screwdrivers, and forceps will enable you to open grills, electrical boxes, and other equipment for inspections. Carry small vials and adhesive labels to collect cockroach specimens. A 10-power (10×) hand lens (small magnifying glass) will help you identify roach species. Colored adhesive labels can be used to mark hot spots, the location of traps and bait stations, and other areas. These tools can be kept in a tool pouch worn on a belt.

Knee pads and bump cap. These are useful when crawling around for floor-level inspections.

However, since cockroaches tend to remain hidden during the day, it is difficult to assess the size and location of a population until after dark. Some individuals schedule at least one inspection after dark, when the majority of the cockroaches are active. This will give you more information about the location of the cockroaches and the level of sanitation at a time when the building is supposed to be clean. Begin your inspection with the lights off, if possible. A flashlight covered with a yellow filter (Roscoe #12) will prevent cockroaches from being disturbed while you look for their harborages and sources of food and water. Then turn on the lights and examine areas where cockroaches were observed. Note this information on your map.

Flushing

Flushing is a method of locating cockroaches in harborages that are difficult to see or reach. It is usually not necessary, especially if you conduct thorough inspections. If you do encounter situations where flushing is necessary, you can use pressurized air (available in an aerosol can) or a hair dryer. A blast of pressurized air will flush the cockroaches from the cracks or crevices. Scattered cockroaches will soon return to the harborage, where they can be monitored and treated.

Monitoring with Sticky Traps

A visual inspection may not provide all the information needed about the location and number of cockroaches, so you may need to use sticky traps as well. Many brands of sticky traps are available, but most have a similar design. They are usually rectangular or triangular cardboard boxes with bands of sticky glue inside. Some models may contain a dark strip that releases a cockroach attractant; these are considered more effective.

The best sites for traps are near harborages and along cockroach travel routes. Cockroaches may not enter traps placed in the open or outside their normal routes of travel. Initially, it is best to place traps near all suspected harborages, water resources, and travel routes. However, avoid placing traps in extremely dusty or moist areas because they will quickly lose their stickiness. The more traps that are used, the sooner the cockroaches can be located. Later, fewer traps can be used for ongoing monitoring. Try to "think like a cockroach" as you decide where to place the traps. A monitoring map and the following examples will help in identifying the best spots.

Trap Locations

Keeping in mind the habitats cockroaches prefer (see Table 4.1 on pages 62–63), place traps in the following types of locations:

- Near and under sinks and stoves
- In or near motors of refrigerators and other appliances or vending machines
- In or near electric clocks, switch plates, and conduits
- Next to computer equipment (where possible)
- Near leaky plumbing fixtures
- Near steam pipes or hot water pipes with insulating jackets
- Near drains
- In drawers and cupboards
- In closets, on their floors and upper shelves
- In false ceilings or subfloor areas
- In areas where packaged goods and equipment are delivered and stored

Trap Placement

Cockroaches are thigmotactic, meaning they like to be in close contact with surfaces. So, it is important that traps be placed against the wall, countertop, etc., and for the opening to be perpendicular to it so a cockroach traveling along the edge of the floor or wall can walk into the trap. Examples for trap placement include:

- Floor and wall junctions
- Floors and cabinets or other solid furnishings
- Floors and appliances (stoves, refrigerators, vending machines)
- Counters and walls
- Hanging cabinets or shelves and walls

Number and date each trap before you put them out. Map the locations (a fire evacuation base map is usually adequate) so none are neglected later. After 24 to 48 hours, count and record the number of cockroaches in each trap. Record the date and the number of cockroaches on the monitoring form. Monitors can be left in place and inspected weekly; they should be replaced monthly—dusty sticky traps don't work!

Evaluating Trap Counts

Use the trap counts located on your map to pinpoint sites of infestation. Traps with high numbers of cockroaches indicate nearby harborages, and this is where management efforts should be concentrated. Traps with few or no cockroaches should be moved to other locations until all main harborage areas are pinpointed. For most programs, even one cockroach is enough to start management methods.

Posttreatment Monitoring to Evaluate Efficacy

After the initial monitoring to pinpoint sites of infestation, treatment efforts can be concentrated at these locations. A week or two after treatment, traps should again be placed at the infestation sites to see how well management efforts are working. Place fresh traps at the previous locations and count the number of cockroaches in the traps after 24 hours. If the trap catch has dropped considerably, the cockroach population has most likely declined and progress has been made. If not, another treatment strategy should be considered and greater efforts must be made to eliminate food, water, and harborage resources. To assess the continued success of treatments and detect any new infestations, continue to monitor after the IPM program is under way. Vigilance is important, and good recordkeeping will save time and energy.

Continuous Monitoring

To avoid future infestations, monitoring should be continued on a monthly or quarterly basis. This will alert pest management personnel to a new invasion before a population can become established. Cafeterias and other food-handling locations should be monitored weekly or at least once a month because of the constant transport of food and packaging (which may contain cockroaches) into and out of these areas. Monitors should be replaced monthly—dusty sticky traps don't work! All monitors should be dated, labeled, mapped, and placed where they will not be disturbed by routine cleaning. Most sticky traps have a peel-off strip, so they may be mounted on the wall, cabinet sides, behind appliances, and so forth.

Sample IPM Plan for a Cockroach Infestation in a Kitchen

1. Use sticky traps to locate cockroach habitat.
2. Lower the cockroach population by vacuuming up cockroaches in areas where traps indicate harborage. Steam-clean infested kitchen equipment and appliances to remove grease if possible.
3. Initiate an education program for students, staff, custodians, and building maintenance personnel to gain cooperation.
4. Inspect all incoming items for cockroaches and their eggs.
5. Improve sanitation and waste management procedures to reduce cockroach food sources.
6. Reduce cockroach access to water and habitat by repairing water leaks, caulking cracks, and scheduling other building repairs. Ensure concealed spaces (such as inside table legs or machine spaces) are sealed and cannot harbor cockroaches.
7. If the previous activities have failed to reduce cockroach numbers, apply insecticidal dusts, baits, or gels in cracks and crevices in hard-to-clean areas. Blow boric acid or silica aerogel into wall voids, underneath appliances, or in other inaccessible areas where roaches harbor.
8. Monitor weekly and fine-tune management methods as needed until the problem has been solved. Continue monitoring monthly or quarterly to ensure sanitation measures are maintained and to detect any incipient buildup of cockroach numbers.

MANAGEMENT OPTIONS

Education

Food service and custodial staff play an essential part in any successful cockroach management program. Provide them with information on how to maintain cockroach-free kitchens, dining rooms, and waste disposal areas by applying the methods described below. Teachers, students, and other staff can play a significant role in maintaining a high level of sanitation in other areas of the school, so they must also be informed of their responsibilities.

Habitat Modification

Cockroaches need food, water, and harborage to survive, with harborage being the primary limiting factor. By modifying the environment of an infested building, you can reduce cockroach access to these resources. Repair leaking pipes and faucets; caulk all cracks. Find hidden spaces, such as inside table legs or other tubular supports, motor compartments, etc.; seal. With good-quality materials (see pages 43–44) and a careful job, these alterations will produce a long-term reduction in the capacity of the structure to support cockroaches. It is important to note that the simple act of increasing the distance between food, water, and harborage will dramatically reduce the number of cockroaches a structure can support.

Limiting Areas for Eating

If you expect to contain and limit pest problems (including rodents and ants as well as cockroaches), it is very important to designate appropriate areas for eating—and to enforce rules about eating only in these areas. The fewer designated

eating areas there are, the easier it will be to limit pests. If food must be consumed in classrooms, the trash must be removed as soon as possible, at least by the end of the day. Floors should be swept/vacuumed and mopped daily.

Proper Food Storage

- Food not kept in the refrigerator should be placed in a sealed container. Cardboard boxes and paper are not cockroach proof.
- Remove food products from cardboard shipping containers before moving them into kitchens or storage areas. Transfer food packaged in cardboard or paper to plastic or glass containers as soon as the food arrives in the building. Do not bring shipping boxes into the food preparation area.
- Screw-top jars are cockroach proof only if the lid has a rubber seal because young cockroaches may be able to follow the spiral ridges to get into the jar.

Sample IPM Plan for a Cockroach Population in an Office or Classroom

1. Initiate an education program for students, staff, custodians, and building maintenance personnel to gain cooperation with the program. Since monitoring and management activities will probably involve desks, computers, lighting fixtures, and other equipment used by staff, it is essential that they be given advance warning that work needs to be done. They should also be made aware that the problem cannot be solved without their cooperation.
2. Place sticky traps to locate roach habitat and prioritize areas to be treated.
3. Vacuum areas where traps indicate cockroaches are living.
4. Improve sanitation and waste management in office, snack, and lunch areas to reduce cockroach food sources.
5. Caulk or seal cracks, and schedule other building repairs to reduce cockroach habitat.
6. If traps indicate that cockroaches have infested computers or other electrical equipment, place bait stations next to infested machines. Never put baits directly on or inside computers or electrical equipment. Never use aerosol insecticides around computers because of the danger of shorting out the equipment. Give office and custodial staff a map showing where bait stations have been placed and request that the stations not be moved. Pesticides must be used in accordance with their EPA-approved label directions, including that it is labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and Safety Data Sheets (SDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label.

   Pennsylvania law allows pesticide applications in schools and childcares only by certified applicators, registered technicians, or noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must also be posted in an area of common access at least 72 hours prior to and for 48 hours after the application of a pesticide in a school building. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied in a school building where students are expected to be present for normal academic instruction or extracurricular activities.
7. If traps indicate that cockroaches have infested electrical conduits and are moving into the room through lighting switch plates, spot-treat the switch box with roach baits, gel, or dust.
8. If traps indicate that storage boxes containing paper files are infested with cockroaches, treat with bait stations or tiny gel bait placements.
9. If the previous activities have failed to sufficiently reduce cockroach numbers, apply roach baits, gel, or dust in cracks and crevices, and blow insecticidal dusts into wall voids, underneath counters, or in other inaccessible areas where roaches reside.
10. Baits incorporating an insect growth regulator (IGR) will help prevent future roach problems.
11. Continue monitoring until the cockroach population has been reduced to a tolerable level. Circulate a memo announcing that the cockroach problem has been solved and thank staff for their cooperation.
12. Continue monitoring on a monthly or quarterly basis to ensure new infestations are detected early.

- Glass containers with rubber gaskets or plastic containers with tight-fitting, snap-top lids are cockroach proof.
- Require students and teachers not to leave unsealed food items in their desks or lockers. Any food kept in offices or classrooms should be stored in ant- and cockroach-proof containers.

Eliminating Water Sources

German cockroaches can survive for a couple of weeks without food, but they must have regular access to moisture or they will die within a few days. Cockroaches find drinking water in:

- Sink traps
- Appliance drip pans
- Drainpipes
- Wash basins and tubs
- Toilet bowls and flush tanks
- Spills
- Condensation on cold water pipes and windows
- Leaky pipes and faucets
- Pet dishes and aquariums
- Vases
- Beverage bottles
- Various high-moisture foods

Much can be done to limit cockroach access to water by increasing sanitation and making repairs. Clean up spills and dispose of drink containers immediately after use. Keep aquariums and terrariums sealed with tight-fitting, screened lids. Repair leaks and dripping faucets, then drain or ventilate moist areas. Kitchen surfaces should be kept dry when they are not in use, especially overnight. (**Note:** Do not apply cockroach baits or gels on or near aquariums; many are highly toxic to fish.)

Eliminating Cracks and Crevices

- Start by caulking where cockroach populations are highest. If cockroaches remain a problem, caulk additional areas.
- Use silicon or mildew-resistant caulk around sinks, toilets, and drains.
- Before beginning the sealing process, vacuum and wash the area to eliminate egg cases, fecal material, and other debris.
- Caulk or paint over cracks around baseboards, wall shelves, cupboards, pipes, sinks, toilets, and similar furnishings in the locations indicated by monitoring traps and where cockroaches could hide (to eliminate potential harborages).
- Screen drain covers in boiler rooms.
- Repair holes in window screens.
- Weather-strip around doors and windows where cockroaches may enter.
- Widen gaps that can't be sealed to make them less attractive to cockroaches. For example, the crack between freestanding shelving and adjacent walls can be widened by simply moving the shelving 1 inch away from the wall.

Eliminating Clutter

Removing clutter from areas near prime habitat such as sinks, stoves, refrigerators, and vending machines is one of the most important components of cockroach management. Clutter in these areas increases the available harborage near food and water. All useless, idle, or outdated items should be removed from the premises, including classroom storage areas. Also, in-house storage of food products and paper goods should be kept to a minimum.

Installing Cockroach-Proof Fixtures and Appliances

Whenever food preparation areas are scheduled for remodeling, the school district can take the opportunity to install cockroach-proof kitchen appliances and fixtures, such as stainless steel open-shelving units. The round shape of the metal and the general openness of the design offer few hiding places for cockroaches. Freestanding storage units and appliances on casters enable them to be rolled away from walls to facilitate thorough cleaning.

Sanitation

Sanitation disrupts and eliminates cockroach resources. This disruption of the environment can play a significant role in slowing cockroach population growth. Sanitation creates an additional advantage by making the cockroach environment so barren that they have a much greater chance of contacting baits or dusts (see "Chemical Controls" on pages 70–72). Thorough daily cleaning is essential.

- Sweep/vacuum and mop the floors.
- Drain all sinks and remove any food debris.
- If children regularly consume snacks in classrooms, sweep/vacuum and/or mop the floors daily.
- Periodically give food preparation areas an all-inclusive cleaning, focusing on areas where

grease accumulates: drains, vents, deep fat fryers, ovens, and stoves. Steam-clean drains and infested appliances. Thoroughly vacuum the area with a powerful vacuum cleaner (see "Vacuuming" below).

- At the end of each day, remove all garbage containing food from the building to prevent cockroaches from feeding at night.
- Use soapy water to wash any bottles, cans, wrappings, and other items that have food residues clinging to them before storing them for recycling. Remove at the end of the day.
- If dishes cannot be washed immediately, it is very important that they at least be rinsed to remove all food debris.
- Place garbage in sealed plastic bags before putting it into a rodent-resistant dumpster or other storage receptacle.
- Keep garbage cans, recycling bins, and dumpsters as clean as possible to deny food to cockroaches as well as ants, flies, mice, and rats.

Brown-banded cockroaches can survive for some time without access to freestanding water and can live on soap or the glue on stamps, so simple sanitation alone will not have as significant an impact on a brown-banded cockroach population as it will on German cockroaches.

Physical Controls

Mechanical Barriers

Pennsylvania wood roaches can travel up the outside of a building and enter through an open window, weep hole, or ventilation duct. Screening these openings will prevent them from using these entry points. Do not seal weep holes; special vent screens are available. The males are also attracted to lights at night. However, Pennsylvania wood roaches are not generally a problem since they need high humidity to survive and usually die within buildings. Screens can also be placed behind grill covers and over vents and floor drains to prevent cockroach entry. Use caulk around the edges of the screen material to make a complete seal. If screening ventilation intakes, ensure the air intake is not impeded. Cockroaches can travel within and between buildings on runways formed by electrical conduits, heating ducts, and plumbing pipes. Seal openings around these runways with caulk, steel wool, or screening material.

Vacuuming

A strong vacuum can be used to pick up live cockroaches and their egg cases and droppings. A vacuum with a HEPA filter (capable of filtering out particles as small as 0.3 micron) will greatly reduce the amount of cockroach debris that becomes airborne during cleaning. Airborne cockroach debris (fecal material, body parts, and cast skins) can cause allergic reactions in sensitive people, including triggering asthma attacks. If the cockroach population is large, vacuuming is a way to quickly reduce the population. Once a large portion of the population has been eliminated, it is much easier to affect the remaining cockroaches with other treatment measures. Although the dust in the vacuum bag will usually clog the cockroaches' breathing apparatus and suffocate them, you can vacuum up a tablespoon of cornstarch to ensure they die. Remove and dispose of bags immediately.

Trapping

Trapping is not a good option due to cockroach allergens. Although traps will often capture a number of cockroaches, in most situations trapping alone will not produce a sufficient degree of control.

Chemical Controls

If nonchemical methods alone cannot solve the problem, integrating a pesticide into your management program may be warranted.

When insecticides are needed, they should be applied as crack and crevice treatments or in a bait formulation. Crack and crevice treatment is the application of small amounts of chemical directly into cracks and crevices where insects hide or enter. This type of treatment is particularly effective against German cockroaches, which spend over 90 percent of their day hidden away in dark cracks, crevices, and voids. Broadcast spraying of insecticides greatly increases exposure risk and can lead to cockroach resistance when the pesticide's residual activity begins to decline and cockroaches are exposed to sublethal doses. This type of general treatment should be avoided whenever possible. If a broadcast spray is necessary, do it when students won't be present for a few days. **Note:** Do not use spray formulation insecticides around computers, as they may short-circuit the equipment. Plastic bait stations can be placed in and around computer equipment if cockroaches establish a harborage inside. Containerized bait stations or gel baits placed into cracks and crevices are exempt from the notification and posting requirements listed below. However, all other pesticide use requirements pertain to these laws, including their application, which must be done by licensed personnel.

Pesticides must be used in accordance with their EPA-approved label directions, including

that it is labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and Safety Data Sheets (SDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label. **Pennsylvania law allows pesticide applications in schools and childcares only by certified applicators, registered technicians, or noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must also be posted in an area of common access at least 72 hours prior to and for 48 hours after the application of a pesticide in a school building. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied in a school building where students are expected to be present for normal academic instruction or extracurricular activities.**

The most recent technological advances in cockroach management have been in bait formulations and insect growth regulators. Other products currently in use include desiccating dusts. Each of these treatment methods is discussed in detail below, including how they can be incorporated into a complete integrated cockroach management program. **Residual pesticides should not be applied where they will be encountered by children; organophosphate insecticides (e.g., propoxur or dichlorvos) should never be used in schools or childcares.**

Cockroach Baits

Cockroach baits consist of a toxicant mixed with a food source. Current indoor bait formulations are applied as bait stations, gels, dusts, or pastes. The bait station is one of the more popular application methods for educational facilities because the stations are easy to place and have residual (long-term) activity. Gel and dust bait formulations are also packaged for injection into cracks and crevices that are not readily accessible. Currently, almost all baiting products available for indoor use are formulated using one of the following active ingredients: boric acid, fipronil, hydramethylnon, indoxacarb, or abamectin. Some of these are in injectable gel formulations or bait station delivery systems. Other formulations include injectable gels in a syringe or bait gun, as well as bait stations, gel aerosols, and flowable bait dusts that can be injected into cracks and crevices. Gels and bait stations may be used interchangeably, whichever is more appropriate or convenient for a location; however, gels are significantly less expensive than bait stations.

Suggestions for cockroach baiting:

- Large blobs of bait in a few locations do not work well. Put out small amounts of bait (about the size of green pea, less than ¼ inch wide) into many crack and crevice locations.
- Put bait near harborage and between harborage and food. Review the "Monitoring" section for examples of cockroach harborage and use the information collected from your monitoring traps.
- Once you have pinpointed harborage areas, place the baits along edges or in places where cockroaches are most likely to travel or congregate. If the bait is between the harborage and the food but not in a place where cockroaches are likely to run into it, the baiting program will fail.
- Sometimes an inch one way or the other can make all the difference in bait placement. If air currents are moving the bait odors away from the cockroach harborage, they may never find the bait.
- Do not place gel baits in areas where they may get covered over with grease, flour, or dust; instead, use bait stations.
- Avoid harsh environmental conditions when baiting. In excessively warm areas, baits can melt and run. In cold environments, cockroaches do not move far and may miss the bait. In very wet environments, the baits may grow mold and become unattractive to cockroaches. Boric acid baits hold up better in the latter situation because boric acid naturally inhibits mold growth.
- Check baits frequently to be sure they have not been completely consumed or inadvertently removed by cleaning.
- Remove old, dried-out bait—it will not be consumed. Remove empty and dispose of bait stations; they are designed to be attractive to cockroaches and may be used as harborages!

Insect Growth Regulators

Insect growth regulators (IGRs) are compounds that disrupt the normal growth and development of insects. IGRs are considered very low-risk compounds. They generally have little toxicity to mammals because they act by disrupting hormonal processes specific to insects. IGRs that

mimic the juvenile hormones of cockroaches (and other insects) are called juvenile hormone analogues (JHAs). JHAs are chemical compounds whose structures are very similar to the hormones that cockroaches produce naturally to regulate development and reproduction. Juvenile hormone analogues disrupt both of these processes. For instance, JHAs interfere with the proper development of last-instar cockroaches. Instead of the nymphs molting into reproductive adults, they molt into "adultoids," which often have twisted wings and are sterile. As more and more cockroaches in a population are exposed to JHAs, the adultoids become predominant. Because the adultoids are unable to reproduce, the cockroach populations slowly decline over time. JHAs are a very effective method of long-term German cockroach management. However, because JHAs do not kill existing cockroaches, they are slow acting, taking from four to nine months to achieve management. For this reason, JHAs are usually applied to cracks and crevices with a sprayer as part of an IPM plan including baits, gels, and dusts. They may also be combined with residual insecticides for difficult populations in mechanical or trash areas. Most of the population is eliminated by the insecticide, and immature cockroaches that survive are sterilized by the JHA.

Insect growth regulators (IGRs) are also available in "point source" dispersal units, small plastic disks that disperse the IGR over a 90-day period. A snap tube is broken (similar to a light stick) to activate. They are mounted with sticky tape, ideally near a heat source (e.g., behind a refrigerator) that will carry the IGR into the room air. These are very easy to use and can enhance the effectiveness of an IPM program, particularly when trying to eliminate an existing infestation.

Inorganic Dusts

Inorganic dusts, such as silica gel and boric acid, are registered pesticides that have frequently been used for cockroach management. These dusts can be applied with a bulb duster into cracks and crevices under sinks and stoves, behind refrigerators, along baseboards, and in electrical outlets, cabinets, and wall voids. Silica gel is finely ground sand or glass that adheres to and abrades the protective waxes on the cockroach cuticle, which causes death from dehydration. Boric acid is a stomach poison that is picked up by cockroaches walking across dusted areas. The boric acid adheres to the cockroach cuticle, and when the cockroach grooms itself, it ingests the boric acid. Refer to the sections on ants and bed bugs for more information about inorganic dusts.

IPM for Fleas

INTRODUCTION

Fleas can be a problem in all parts of the country except very dry areas. The most common species in school buildings is the cat flea *(Ctenocephalides felis)*. This flea feeds on cats, dogs, and humans, as well as rodents, chickens, opossums, raccoons, and other animals. The dog flea *(C. canis)* and the human flea *(Pulex irritans)* are less commonly encountered.

IDENTIFICATION AND BIOLOGY

Adult cat fleas are small (⅛ inch long), wingless insects with powerful hind legs that are adapted for jumping and running through hair. The adult body is reddish brown to black, oval, and laterally flattened **(FIGURE 5.1)**. Unlike many other flea species, adult cat fleas remain on their host. After mating and feeding, adult female fleas lay oval, white eggs (1/50 inch in diameter). These smooth eggs easily fall from the host into cracks, crevices, carpet, bedding, or lawn covering. A mature female flea can lay up to 25 eggs per day for three weeks.

Small, wormlike larvae (1/16 to 3/16 inch long) hatch from the eggs in 2 to 12 days. They have a distinct brown head and are eyeless, legless, and sparsely covered with hairs. The larval body is translucent white and a dark-colored gut can be seen through the flea's skin. Flea larvae feed on dried blood excreted by adults, but they will also eat dandruff, skin flakes, and grain particles. Larvae live in cracks and crevices or on the ground where eggs have fallen. Under favorable conditions, they take 8 to 21 days to develop, but they can take up to 200 days under unfavorable conditions. Larval fleas eventually spin silken cocoons in which they metamorphose into adults. The cocoons are sticky and attract dirt and debris, which camouflages them. Under optimal conditions, new adults are ready to emerge from their pupal cocoons within 2 weeks. They can, however, remain in their cocoons for up to 12 months in the absence of a host or under unfavorable climatic conditions. Vibrations and/or elevated temperature stimulate adults to emerge from their cocoons. This ability to wait until a host arrives can result in a sudden increase of adult fleas when they emerge simultaneously from many cocoons.

As soon as the adult fleas emerge from the pupal case, they seek a host from which to take their first blood meal. Adults can live for one to two months without a meal and can survive for seven or eight months with one. They are the only stage that lives on the host and feeds on fresh blood. The flea population builds up all year long in the form of eggs, larvae, and pupae, but rapid development into biting adults cannot be completed until temperature and humidity are optimal and host cues signal for adult emergence from the pupal cocoon.

ASSOCIATED PROBLEMS

Flea bites cause irritation and sometimes serious allergic responses in animals and humans. Other more serious yet far less common problems are associated with the cat flea. Cat fleas can carry or transmit various organisms, such as *Yersinia pestis*, which causes bubonic plague; *Rickettsia typhi,* which causes murine typhus; and *Dipylidium caninum*, the double-pored dog tapeworm, which can live in dogs, cats, or humans.

DETECTION AND MONITORING

Fleas can be a problem in schools even when there are no pets in the buildings. Adult fleas can be brought in on the clothing or belongings of staff, students, or visitors. Other possible sources include urban wildlife such as rats, feral cats, raccoons, opossums, chipmunks, squirrels, or birds that may

PEST AND DISEASES IMAGE LIBRARY, BUGWOOD.ORG

FIGURE 5.1. Adult cat flea.

Sample IPM Plan for an Indoor Flea Situation

If monitoring has confirmed a high indoor flea population that requires an immediate response, the following IPM program can be used to manage the situation. A significant reduction of flea numbers should occur within one or two days.

1. **Protect yourself.** Wear long pants tucked into boots or socks. For added protection, you may want to apply an approved insect repellent to pant legs and footwear.
2. **Vacuum and/or steam-clean infested areas.** Since most fleas reside in carpeting, it should be thoroughly cleaned. In uncarpeted areas or where carpeting cannot be steam-cleaned, concentrate vacuuming along baseboards, under furniture, behind doors, or in other areas where dust collects and flea eggs are protected from foot traffic. See "Physical Controls" on pages 75–76 for more details.
3. **Apply an insect growth regulator (IGR).** After completing steps 1 and 2 above, spray carpets and floor with an appropriately labeled IGR (see "Chemical Controls" on page 77). The IGR will prevent pre-adult fleas that survive vacuuming or steam-cleaning from maturing into biting adults. Pesticides must be used in accordance with their EPA-approved label directions, including that it is labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and Safety Data Sheets (SDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label. **Pennsylvania law allows pesticide applications in schools and childcares only by certified applicators, registered technicians, or noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must also be posted in an area of common access at least 72 hours prior to and for 48 hours after the application of a pesticide in a school building. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied in a school building where students are expected to be present for normal academic instruction or extracurricular activities.**
4. **Apply an insecticide if needed.** The first three steps described above should reduce the flea population to a low level and keep it there while long-term measures (such as locating and removing wild animal flea hosts from the building) are undertaken. If sufficient management has not been achieved, an application of a borate insecticide to carpeting or spot treatment of infested areas with pyrethrin (see "Chemical Controls" on page 77) may be necessary. If adequate management still has not been achieved, a pest management professional should be contacted to apply a stronger insecticide, such as a synthetic pyrethroid. A combination of both an IGR and another appropriately labeled pesticide may be needed in some cases. These treatments must be made by appropriately certified personnel, all label directions should be followed, the applicator should wear appropriate protective clothing as stated on product labels, and the application must be made in accordance with Pennsylvania laws and the school/childcare IPM plan.
5. **Remove any wildlife nesting in or under the building.** If flea problems persist, but no pet is present, check for wildlife in the vicinity of the building. If any wildlife is found, it needs to be removed by a Nuisance Wildlife Control Operator. If you have any questions or concerns about wildlife and its removal, please contact the Pennsylvania Game Commission at 717-783-6527. A residual insecticide may be needed under buildings to prevent flea migration indoors (see "Chemical Controls" on pages 76–77 and the pesticide application laws stated above).

live in parts of the building. Detection is as simple as seeing fleas or noticing bites around the ankles of people in the building. Flea dirt (adult flea feces that dries and falls off a host) may also be visible.

Areas to Monitor

- In and around the cages of pets kept in classrooms (also check the pets themselves for signs of fleas)
- Places where animals might find harborage, such as basements, crawlspaces, attics, eaves, rooftop structures, and secluded shrubbery near buildings

Monitoring Traps

Flea Sock Traps

These are homemade, knee-high, white flannel booties that fit over the shoes and lower pant legs.

When you walk through a flea-infested area, fleas will jump onto the flannel and become temporarily entangled in the nap, where you can easily see and count them. Long, white athletic socks worn over the shoes and trouser legs will also work, as will wide strips of sticky-backed paper wrapped around the lower legs (sticky side out). Socks can also provide protection from bites if a person must enter a severely flea-infested area for a short period of time.

Light Traps

These compact traps, roughly 4 by 6 inches in size, consist of a small electric light and a sheet of sticky paper. Adult cat fleas seeking a host appear to be attracted to both the warmth of the trap and the light emanating from it. Research has shown that fleas are most attracted to green light and are more attracted to light traps if the light is turned off for 10 seconds every 5 to 10 minutes; therefore, it is important to use a trap with a green light that can flicker on and off. Light traps are especially useful for monitoring in offices or classrooms where no animals are present and the flea population is likely to be small. Check the traps once a week. If no fleas are caught by the second week, move the trap to another location or remove it. If the traps catch only a few fleas, the infestation is very small and can probably be managed with the traps alone. In this case, leave the traps in place until no fleas have been caught for at least a week. More fleas caught per trap in a week indicates a more serious infestation, and time must be devoted to finding its source (such as an animal living in or under the building).

Persistent Flea Problems

Persistent flea problems in buildings where there are no pets may indicate the presence of rodents or other wildlife. In this case, it may be helpful to have a professional identify the fleas. A flea's identity can be used to determine the host animal and where to search for the host or its nest.

MANAGEMENT OPTIONS

An integrated pest management program for fleas can be designed by selecting from the following strategies and tactics. See the sample emergency flea management plan on the previous page.

Physical Controls

Wild Animal Removal

Wildlife needs to be removed by a Nuisance Wildlife Control Operator. If you have any questions or concerns about wildlife and its removal, please contact the Pennsylvania Game Commission at 717-783-6527. Make appropriate repairs to exclude animals.

Vacuuming

- Vacuuming on a regular basis throughout the year will keep developing flea populations low by eliminating adult fleas and their eggs.
- Vibrations caused by vacuum cleaners will stimulate new adult fleas to emerge from their pupal sacs. These new adults will either be exposed to any residual insecticide on the floor or captured in the next vacuuming.
- Vacuuming is not very effective at capturing flea larvae in carpeting because the larvae coil themselves around the fibers. Vacuuming does, however, remove the dried blood on which the larvae feed.
- Use vacuum attachments to clean cracks and crevices. Caulk or seal these openings.
- Most fleas will be killed when dust in the vacuum bag suffocates them. To be sure they are killed, you can vacuum up a tablespoon of cornstarch.
- Vacuum badly infested areas thoroughly every day for at least three weeks, until the infestation is managed.
- When infestations are severe, you may need to supplement vacuuming with steam-cleaning or other management tactics.

Steam-Cleaning

The services of a steam-cleaning firm may be warranted when flea populations are severe. This process kills adult and larval fleas and probably some eggs as well; however, since the warmth and humidity from the steam also stimulate the remaining flea eggs to hatch a day or two after the cleaning, some fleas may reappear. If the other steps recommended in this section are followed, the few fleas that hatch after steam-cleaning should represent the last of the flea population.

Flea Combs

Classroom pets in a flea-infested room should be combed regularly with a special flea comb that can be purchased at a pet store. Fleas and eggs removed from the animal should be dropped into soapy water, and the comb should be washed thoroughly.

Laundry

Wash removable floor coverings, such as rugs, located in areas where there are known

infestations. Any bedding for classroom pets should also be washed regularly.

Ultrasonic Devices

It has been suggested that ultrasonic flea collars keep fleas off pets, but recent investigations have shown these devices to be ineffective.

Heat

Tests have indicated that cat flea larvae die after exposure to 103°F for one hour, and techniques to raise the temperature in a room to provide this exposure have been developed. The heating process uses a common heating unit modified to include special blowers and flexible ducts. Companies have been using heat to kill bed bugs, termites, and woodboring beetles for a number of years, and now some companies are experimenting with heat to manage fleas. One potential problem with this technique is that fleas can burrow into carpets and upholstery and perhaps escape lethal temperatures.

Drying or Flooding Infested Areas Outdoors

Outdoors, organic matter can temporarily harbor flea larvae. Either drying out these areas or saturating them with water will kill eggs and larvae. You can also treat these areas with insect-attacking nematodes (see "Biological Controls" below) or an insecticide labeled for outdoor use (see "Chemical Controls" on page 77).

Biological Controls

Beneficial Nematodes

Insect-destroying nematodes *(Steinernema carpocapsae)* can be applied to the lawn as a spray. These microscopic, wormlike organisms live in the soil and kill insects by entering their bodies, feeding on their tissue, and releasing harmful bacteria. They do not affect people, pets, or plants. When the nematodes mature and reproduce, the nematode larvae leave to search for other hosts. They cannot move far (only 1 or 2 inches) and die if they fail to contact other insects. The nematodes sold for flea management are native to the United States and are found naturally in the soil nationwide. They will not adversely affect earthworms but may attack insects other than fleas. Nematodes may not be effective in some situations and may also require monthly applications.

Tips for using nematodes:

- Use the number of nematodes recommended by the manufacturer.
- Treat outdoor areas where you have found evidence of sleeping animals or areas that you know are regularly traveled by animals.
- Moisture is critical to the effective use of nematodes, so water the area before and after the application.

Chemical Controls

If nonchemical methods alone are ineffective or only partially effective, then integrating a pesticide into your management program may be warranted. Pesticides must be used in accordance with their EPA-approved label directions, including that it is labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and Safety Data Sheets (SDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label. **Pennsylvania law allows pesticide applications in schools and childcares only by certified applicators, registered technicians, or noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must be posted in an area of common access for applications made at or in a school building at least 72 hours prior to and for 48 hours after the application. For applications made on school grounds the sign must be posted at the place to be treated at least 72 hours prior to and for 48 hours after the application. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied in a school building or on school grounds where students are expected to be present for normal academic instruction or extracurricular activities.**

Diatomaceous Earth and Silica Aerogel

Diatomaceous earth (DE) is made from fossilized diatoms, and silica gel is produced from sand. Both products kill insects through desiccation—they abrade the wax and oil on the insect's outer covering, leading to dehydration and death. Although these materials are not poisonous to humans, the fine dust travels freely through the air and can be irritating to the eyes and lungs; therefore, use a dust mask, goggles, and any other appropriate person protective equipment in accordance with

label instructions during application. Silica gel and DE are sometimes formulated with pyrethrins, which are discussed below.

How to use DE and silica aerogel:

- Lightly dust upholstered furniture that is suspected to harbor fleas. Be sure to work the material into cracks and crevices. Do **not** put DE on seats or surfaces that will contact people, as it will cause extreme itching.
- Lightly dust rugs or pet bedding, leave for a couple of days, and then vacuum up.
- Apply to infested carpeting, leave for a couple of days, and then vacuum up.
- Dust crawl spaces, wall voids, attics, and other similar spaces where you suspect animals of nesting or resting.
- Do not use in moist environments; neither material works well when wet.

Citrus Oil Extracts (D-Limonene/Linalool)

D-limonene and linalool are citrus-peel extracts that have been used for years as food additives. Products that contain d-limonene kill larval and adult fleas, while those containing both ingredients kill all flea stages. EPA-registered citrus shampoos are mild enough to use on young animals, but veterinarians caution that some cats may react negatively if the material is applied in excessive concentrations. Citrus sprays can also be applied to animal bedding, but they should not be used outdoors or to spray entire rooms.

Borates

Borate products worked into the nap of the carpet can be used to manage fleas. This treatment is an intestinal poison that acts on flea larvae that have ingested it. These products may be effective for up to a year. Borate products are sold through veterinarians, but application of borates by a licensed pest management professional is required in schools and childcares.

Pyrethrins and Synthetic Pyrethroids

A number of flea management products containing pyrethrins and synthetic pyrethroids are used as spray treatments to reduce the number of fleas. These products should be applied by a licensed pest management professional.

Insect Growth Regulators

Insect growth regulators (IGRs) inhibit the development of immature fleas but do not kill adult fleas. Use of an IGR product (or a borate product) in conjunction with an adulticide (imidacloprid, fipronil, pyrethrins, or pyrethroids) prevents the development of immature fleas and kills adult fleas. Methoprene and pyriproxyfen are available in pet sprays, pet collars, and spot treatments. Fenoxycarb is available through professional pest management companies and is for outdoor use only. Lufenuron, a medicine for dogs and cats, is available only from veterinarians. It manages fleas by preventing eggs from hatching.

IPM for Flies

INTRODUCTION

Many species of flies can be problems in schools. Each kind of fly has a distinct breeding site inside or outside the school building. To manage pest flies, you must know which fly is causing the problem and where it is breeding. Common pest flies encountered in schools can be identified by the characteristics shown in **TABLE 6.1**.

IDENTIFICATION AND BIOLOGY

Cluster Flies

Cluster flies are larger and darker than house flies and have a distinctive yellowish color caused by the crinkled yellow hairs on their bodies. In the summer, cluster flies lay their eggs in soil, where the maggots parasitize earthworms. Soil containing many earthworms is a common source of these flies. In the fall, the adults can be seen clustering on the south and west sides of buildings. As the weather gets cooler, these flies begin looking for sheltered places to spend the winter and often enter buildings.

Fruit or Vinegar Flies

Fruit or vinegar flies are small flies commonly seen flying around ripe fruit, especially bananas. They are about ⅛ inch long. They lay their eggs near the surface of fermenting fruits and vegetables and other moist organic materials (including damp mops, cleaning rags, and residues in bottles, cans, garbage disposals, and drains). Their life cycle, from egg through maggot and pupa to adult, takes little more than a week, and the number of flies that can be produced by a single piece of fruit is enormous. These flies are most often a problem in late summer and early fall, so careful storage of fruit and vegetables is especially necessary at these times of the year.

House Flies, Dump Flies, and Blue and Green Bottle Flies

House flies, dump flies, blue and green bottle flies, and others that breed in food wastes (garbage) and/or animal feces are generally referred to as "filth flies." Sometimes flies are confused with wasps; however, flies have two wings, while wasps and all other winged insects have four wings arranged in two pairs. Wasps, unlike flies, fold their wings alongside their bodies when at rest. Most pest wasps are colorfully marked with yellow, red, black, and white, and have narrowly constricted waists. Generally, wasps are less likely to come indoors, are aggressive in their flight around foods, particularly sweets, and are larger than filth flies. Filth flies are not aggressive and do not bite. The cluster fly, which is also larger than the filth flies, can be identified by its stout body with crinkled yellow hairs.

Filth flies pass through four distinct stages in their life cycle: egg, larva (maggot), pupa, and adult. Adult female filth flies look for moist places with the right smell to lay their eggs. This can be in food waste in a garbage can or dumpster, dog or cat feces, dead animals, kitchen drains, grass clippings allowed to rot in a pile, and even moist soil that is mixed with garbage. The larva hatches from the egg and grows until it is ready to form a puparium (a kind of cocoon), from which an adult fly will emerge. Once the adult fly emerges, it doesn't grow any larger; small flies do not grow into larger flies.

Moth Flies (Drain Flies)

Moth flies (*Psychoda* spp.) are about 1/16 to ¼ inch long, fuzzy, and dark or grayish. Their body and wings are densely covered with hairs. Wings that appear too large for the body are held rooflike over the body when at rest, giving a mothlike appearance. During the day, adults often rest in shaded areas or on walls near plumbing fixtures and on the sides of showers and sinks. During the evening, these flies can be seen walking about drains and sinks. They may breed in large numbers at sewage filter plants and then be carried by prevailing winds to nearby buildings up to a mile away. Adults are small enough to pass through ordinary window screening.

Phorid Flies (Humpbacked Flies)

The most common phorid fly, *Megaselia scalaris*, is small (1/16 to ⅛ inch long) with a yellowish-brown body and light-brown wings. The adults seem reluctant to fly, and they run around on walls, windows, and tables with a characteristic quick, jerky motion. The females are strongly attracted to odors and lay their eggs on or next to decaying material, both plant and animal. Food sources for the larvae are highly varied, from decomposing fruit, vegetables, and meat, to open wounds in animals and people, to human and animal feces. The life cycle from egg to adult takes from 14 to 37 days.

Table 6.1. Common Flies Found in and around Schools/Childcares in Pennsylvania

SPECIES	DESCRIPTION	SOURCES OF INFESTATION
Blow Flies		
Green Bottle Fly (*Phaenicia sericata*), **FIGURE 6.1A**	¼ to 5/16 inch long; shiny green to bronze	Garbage containing mixtures of animal and vegetable matter; dead animals; fresh meat; enters buildings less frequently than house flies
Blue Bottle Fly (*Cynomyopsis cadaverina, Calliphora* spp.), **FIGURE 6.1B**	¼ to 9/16 inch long; thorax dull; abdomen metallic blue	Exposed meat, feces, overripe fruit, and other decaying vegetable matter; enters buildings in cool season
Cluster Fly (*Pollenia rudis*), **FIGURE 6.1C**	Larger than house fly; ⅜ inch long; larvae dark gray with distinctive yellow hairs; adults sluggish	Parasitic on earthworms; adults enter houses in fall
Fruit or Vinegar Fly (*Drosophila* spp.), **FIGURE 6.1D**	⅛ inch long; yellow brown	Fermenting fruit and vegetables, other moist organic matter
House Fly (*Musca domestica*), **FIGURE 6.1E**	¼ to 5/16 inch long; gray; four stripes on thorax	Garbage, human and animal feces
Moth Fly or Drain Fly (*Psychoda* spp.), **FIGURE 6.1F**	1/16 to ¼ inch long; dark or grayish with wings densely covered with hairs	Eggs, larvae, and pupae often found in slime or muck in drains, sewage disposal beds, moist compost, and garbage containers; adults found near same areas
Phorid Fly or Humpbacked Fly (*Megaselia scalaris*), **FIGURE 6.1G**	1/16 to ⅛ inch long; more hump-backed in appearance than fruit flies	Decomposing organic matter, including vegetables, fruit, flesh, and feces; grease

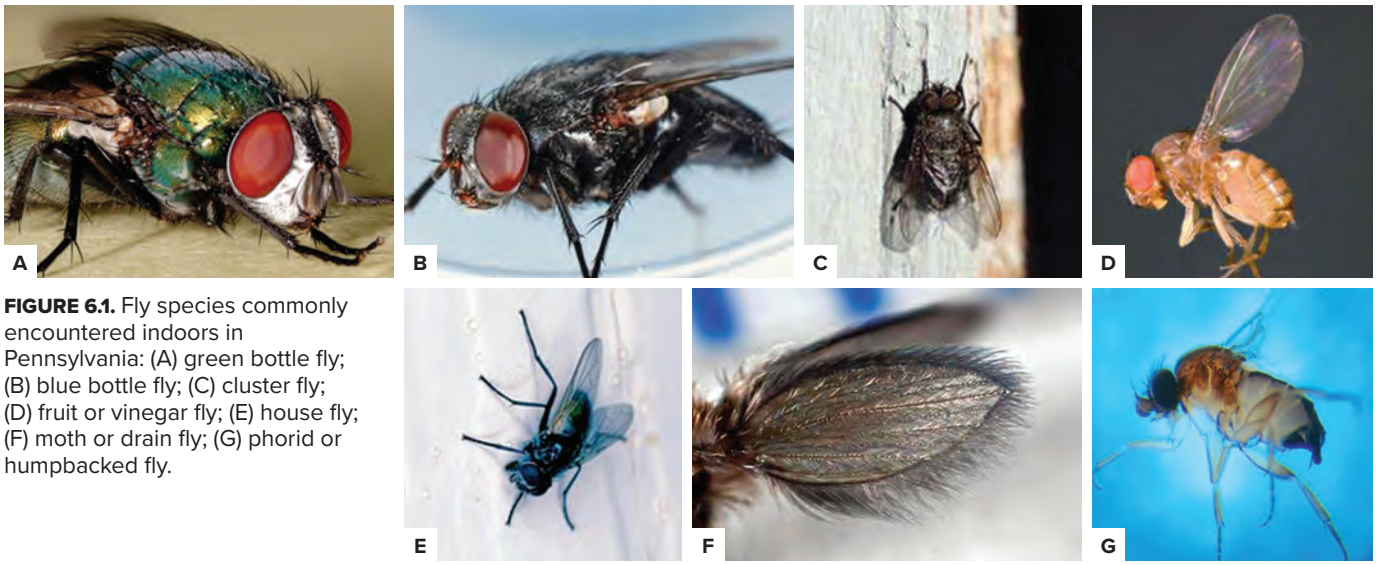

FIGURE 6.1. Fly species commonly encountered indoors in Pennsylvania: (A) green bottle fly; (B) blue bottle fly; (C) cluster fly; (D) fruit or vinegar fly; (E) house fly; (F) moth or drain fly; (G) phorid or humpbacked fly.

(A, B, E, F) JOSEPH BERGER, BUGWOOD.ORG; (C) WHITNEY CRANSHAW, COLORADO STATE UNIVERSITY, BUGWOOD.ORG; (D) PEST AND DISEASES IMAGE LIBRARY, BUGWOOD.ORG; (G) SANFORD D. PORTER, USDA-ARS CENTER FOR MEDICAL, AGRICULTURAL, AND VETERINARY ENTOMOLOGY, BUGWOOD.ORG

DAMAGE

Flies that invade cafeterias and kitchens are not just a nuisance; they also carry bacteria and other microbes that can contaminate food, utensils, and surfaces.

DETECTION AND MONITORING

It is important to correctly identify the problem flies and pinpoint their breeding sites. Some of the characteristics listed in Table 6.1 can help you with identification. Specimens can also be taken to a Penn State Extension educator, who should be able to assist in identification. To collect specimens inside, use sticky flypaper or gather dead specimens from windowsills and light fixtures. Outside, trapping is one of the easiest methods of catching flies for identification (see pages 82–84 for guidelines on trap construction, placement, and baits). If adult flies consistently avoid baited traps, the pest fly may not be a filth fly.

MANAGEMENT OPTIONS

To manage flies, you must find and reduce breeding sites, install and maintain screens to keep flies out of buildings, kill with a fly swatter or

flypaper those flies that do get inside, and reduce or eliminate the odors that attract flies.

In a school with a frequent waste removal program, it is very possible that few flies are breeding on the school property. It is more likely that odors from dumpsters, garbage cans, kitchens, and cafeterias are attracting flies to the school from the surrounding neighborhood. House flies and blow flies, the species that most commonly invade buildings, usually develop outside and follow odors into the building. They can also be pests when students or staff are eating outside. In schools where waste removal is infrequent, fly populations can be breeding at the waste collection site.

Cluster flies are not as strong fliers as house flies and can easily be killed with a fly swatter or removed with a vacuum. Cluster flies can also be allowed to exit by opening the window. They can find their way into buildings through unscreened doors and windows, openings under siding and around roofs, unscreened ventilating spaces, cracks around windows, and holes where wires penetrate the walls of the building. During warm winter periods, cluster flies hidden in buildings become active and are attracted to windows.

Fruit flies are most active from early summer through early fall. Problems with these flies can be avoided by ripening fruit in paper bags. Seal the bags by folding the top over several times and closing them with paper clips or clothespins. Once fruit is ripe, store it in the refrigerator. Careful storage of fruit during the rest of the school year may not be necessary. If an infestation is discovered, look for and remove the material that is breeding the flies. Begin by searching for the obvious sources, such as ripe fruit and vegetables, then look at water from refrigerators, humidifiers, or sink drains that may be fermenting, spoiled animal food, or even damp, sour mops or rags. Areas outside the building near windows and doors should be checked for rotting vegetable matter. All breeding sources should be removed and disposed of in a sealed plastic bag. Make sure that screens and windows near food preparation areas are in good repair.

Moth flies do not bite humans, but they may become a nuisance by their presence in large populations. Concentrate on eliminating larval breeding sites from drains in floors, sinks, wash basins, showers, and similar places. To determine if the flies are coming from a drain, place a glue board, sticky side down on a collar made of cardboard, over the drain during a down time. Leave in place overnight or for a few days to monitor for the flies. Often the most effective method is to clean the drainpipes and traps regularly to eliminate the gelatinous, rotting organic matter, thus eliminating the larval food source. Infestations developing in drains can often be eliminated by flushing these areas with sink-cleaning materials followed by very hot water. Drain gels may be used. These enzymatic cleaners digest grease and organic matter in drains. Do not use caustic chemicals to clean drains. Do not use brushes when cleaning drains, as this may cause contamination of the kitchen from *Listeria*, which is often present in drains. Clean dirty garbage containers, standing water in air conditioners, or other sources of stagnant water in the area.

Phorid flies breed in diverse sources of organic matter, so it may take considerable sleuthing to find their breeding sites. Once a site is found, it must be thoroughly scraped, cleaned, and dried. Large infestations of these flies are often the result of broken drains or garbage disposals that allow organic matter to accumulate in out-of-the-way places such as in wall voids, under floors, in basements, or in the soil of crawl spaces. They will also enter kitchen vents, attracted by grease, when the fans are off. Clean residues and screen outlets, if necessary.

Habitat Modification

Modifying the habitat is one of the most important aspects of fly management. It is impossible to manage filth flies without controlling wastes and odors.

Food Waste

- All food waste from the kitchen, cafeteria, and other areas should be separated from other garbage, drained so it will be as dry as possible, and then stored in sealed plastic bags before discarding.
- Place containers with small amounts of food waste, such as milk or yogurt cartons, into sealed plastic bags before disposal. This will reduce access by flies.
- Promptly fix leaky drains or electric garbage disposal units and/or drains that allow food waste to accumulate under sinks or floors. Leaky drains can attract many species of flies. Remove any food waste that has accumulated under sinks or floors or in crawl spaces or basements at the site of the broken drain, and then clean the area thoroughly. Floor drains may be cleaned with enzyme products that dissolve organic matter; consult your cleaning products supplier and follow label instructions. Do not use brushes to clean drains, as

this can spread *Listeria*, an important food-borne bacterium.

Other Garbage

In food preparation areas, rinse all cans, bottles, and plastic containers before recycling or discarding.

Exterior Garbage Cans and Dumpsters

- Inform students, teachers, and staff about the importance of placing garbage inside the proper containers. Garbage should not be left lying on the ground.
- To avoid attracting flies into the building, place dumpsters and recycling containers upwind from the outside doors of the school, particularly doors to the kitchen or cafeteria. When dumpsters are downwind, flies are attracted to the waste odors and then find the odor trails that the breeze blows down from the doorways. Following these odor trails, they find their way into the building.
- Waste should be collected and moved off-site at least once a week. Because flies breed faster in warm weather, garbage collection twice a week may significantly reduce fly problems.
- Make sure garbage can and dumpster lids seal tightly when closed and remain closed when not in use. Do not leave lids open at night; garbage can attract other pests, such as rodents. Repair or replace garbage cans that have holes or lids that do not close tightly.
- Regularly clean garbage cans and dumpsters to prevent the buildup of food waste. Use a high-pressure stream of water or a brush and soapy water, if necessary. A solution of baking soda and water will eliminate odors. Do not allow soured milk to collect in trash receptacles; it is a powerful attractant to flies. If possible, dumpsters should be fitted with drains so they can be hosed or scrubbed out as needed. Another option is to require the refuse company to clean the dumpster or replace it with a clean one more frequently. Some pest management companies will power-wash dumpster and dumpster areas as part of their service.
- Flies can develop in soil soaked with water used to clean garbage cans and dumpsters. Check these areas regularly. If you see maggots, scrape them up along with the soil and dispose of everything in a tightly sealed plastic bag.
- Inspect dumpsters and other outdoor trash receptacles daily, and remove any waste lying on the ground.
- Garbage cans on the school grounds should have removable domed tops with self-closing, spring-loaded swinging doors. Cans should be lined with plastic bags that can be tightly sealed and removed daily.
- If children do not have access to dumpsters, baits inside and residual insecticides on the outsides of dumpsters work well. This option requires a properly certified individual to apply the treatment according to state law and the school/childcare's IPM plan.

Animal Feces

Remove droppings promptly and put them into plastic bags that are sealed before disposal. Dog feces that dry quickly may attract adult flies with their odor but are unlikely to host many maggots. Droppings that remain damp because of humidity or rain can breed a number of maggots.

Odor

Flies can detect odors across long distances. Smells of souring milk from hundreds of containers thrown in dumpsters can attract thousands of flies from the surrounding neighborhood. Storing garbage in sealed plastic bags and having cans and dumpsters cleaned and emptied frequently to eliminate odors is very important. Removing pet feces also helps reduce odors that attract flies. Flies attracted to open kitchen or cafeteria doors, dumpsters, or garbage will rest on nearby walls, eaves, and rafters. While resting, they leave fly specks, which have a strong fly-attracting odor. These brown to cream-colored specks should be washed off with an odor-eliminating cleaner (a mild solution of baking soda and water can be particularly effective); otherwise, they will continue to attract flies.

Physical/Mechanical Controls

Screens

Install screens over windows, doors, and vent holes to prevent flies from entering buildings. Weatherstripping or silicone caulk can be used to ensure a tight fit. Torn screens can be repaired with clear silicone caulk. Screen doors should be fitted with springs or automatic closing devices that close the screen door firmly after it is opened. External doors that cannot be screened should be fitted with automatic closing devices and/or

vertical strips of overlapping plastic that allow human access but prevent fly entry. "Air curtains" that force air across openings are another alternative to screen doors.

Fly Swatter

In many instances, the old-fashioned fly swatter is the safest and quickest way to kill flies that have found their way into a room. Aim the fly swatter about 1½ inches behind the fly, rather than directly at it, because research has shown that when a house fly takes off from a horizontal surface, it jumps upward and backward. Stiff plastic swatters seem to work better than wire-mesh ones. The fly's unblurred range of vision is about 1½ feet, and the swatter can be moved to this distance before striking.

Flypaper

Sticky flypaper is effective at catching flies because it takes advantage of their natural habit of moving up to the ceiling to rest. It will take several days for a new strip of flypaper to start catching flies. Use a number of strips at a time and replace them when they are covered with flies or begin to dry out. Flypaper can be very useful in areas where there are too many flies to kill with a fly swatter and aesthetic appeal is not of primary importance. Flypaper is also a useful monitoring tool. Do not place flypaper or sticky strips above or near food preparation areas.

Fly Traps

Fly traps can be used to reduce adult fly populations, capture specimens for identification, and monitor the effectiveness of management programs. Fly traps are not toxic and are more selective than using insecticide. Sticky traps are available as cards, tubes, or other shapes and often "baited" with pictures of flies—flies are attracted to rest where they think other flies are. Traps need to be serviced regularly, placed appropriately, and repaired or replaced when damaged.

Fruit fly trap: To make a simple trap for fruit flies, combine 1 cup of vinegar, 2 cups of water, and 1 tablespoon of honey in a 2-liter soda bottle. Replace the cap, shake the mixture well, and punch holes in the side of the bottle above the liquid so the flies can get in but cannot find their way back out. Using string, hang the bottle about 5 feet above the ground. Periodically, the dead flies should be strained out and the liquid reused.

Trapping flies indoors. Electrocuting light traps often are used indoors. The Food and Drug Administration states that they should be "installed no closer than 5 feet from exposed items." Light traps will not work well in a room with many and/or large windows because the bright light coming in the windows is a much more powerful attractant than the comparatively weak light coming from the trap. Light traps do work well at night. Some companies are now producing fly traps that lure the flies to a hidden glue board with a near-UV blacklight specially designed to attract flying insects. These were developed for cafeterias, fast food operations, and school lunchrooms. Contrary to the advice provided in some promotional literature for ultraviolet light or electrocutor traps, these traps should not be used outdoors. They are relatively nonselective in the insects they attract and will kill many more beneficial and innocuous insects than pests.

The following are key points to remember when using insect light traps for indoor flies:

- Use the number of traps recommended by the manufacturer or, as a general rule, one trap for every 30 feet of wall.
- Ideally, traps should be mounted 3 to 5 feet from the floor on the perimeter walls of the room because hungry flies circle the perimeter of a room close to the floor when looking for food. They should also be placed 5 feet away from any open food and 25 feet from any doors or windows. Traps work best in rooms without windows. In large food storage areas, a ceiling-mounted insect light trap can help control night-flying flies, moths, and other pests. A pest management professional can help with trap placement recommendations.
- Empty and clean the traps weekly to prevent dead flies from becoming an attractive food source for other insects.
- Replace lamps at least once a year.
- The more expensive blacklight "blue" bulbs do not attract more flies than regular blacklight bulbs.
- The lamp should be directed toward the interior of the building. Do not place traps where flies that are outside can see the light bulb. This may attract more flies.
- Place traps near odor sources such as cooking areas, garbage cans, and outdoor restrooms because odors will be more attractive (especially from a distance) than the light.

Trapping flies outdoors. To capture flies outside, use traps with a screen cone suspended above the bait. These cone-type traps take advantage of the fly's habit of flying or walking toward light. Cone traps can easily be made from

wood and aluminum or plastic screening; use the dimensions shown in **FIGURE 6.2**. Flies are attracted to the bait in the pan under the trap. Once the flies are under the trap, the brightest spot they see is the hole in the cone above them. They walk up through the hole and are trapped in the outer screen cage. Since flies are attracted to the light and it is always lighter above them, they cannot find their way back out through the hole in the cone.

The following are key points to remember when trapping flies outdoors:

- Trap placement is important.
  - If an area has a small or moderate fly problem, traps placed close to buildings can attract flies from all over the neighborhood and make the problem worse. It is better to set the traps close to fly breeding sites, with any prevailing breeze blowing from the trap toward the breeding area.
  - Do not set traps near doorways or entrances to buildings.
  - Place traps away from outdoor areas that are used for eating or recreation.
  - Generally, traps are most effective when placed on the ground, but they can also be hung over the openings of dumpsters and from buildings or fences. Traps hung in these areas must not interfere with the opening and closing of the dumpster and should be placed in areas where people will not tamper with them or be offended by the bait odors.
  - Place traps in sunlight. Flies are more active in sunlight, both outside and inside the trap.
- Empty the trap when dead flies cover about one-quarter of the cone. Do not release live flies that are in the trap. Kill them by enclosing the trap in a plastic bag and placing it in the sun. After the flies are dead, the contents of the trap should be poured into the plastic bag, sealed, and discarded in a dumpster or garbage can.
- Do not clean the trap between uses. The smell of the millions of fly specks deposited on the screen is very attractive to flies.
- Liquid bait, either the Yeast Bait or the Beltsville Bait, is a superior attractant that will not breed flies unless it is allowed to dry to a sludge. If either of these baits contaminates clothing and hands, use baking soda and water to remove the odors.
- Yeast Bait has a foul odor that is particularly attractive to female flies because it smells like a good place to lay eggs. This bait will lure flies even from the most attractive breeding sites.
- Beltsville Bait will attract male flies as well as females because it contains sugar. This sweet bait can be used in cool weather when the main aim of trapping is to reduce the total number of flies rather than suppress breeding.
- Baits such as decaying meat or fish scraps will attract mainly blow flies and flesh flies. These baits should always be put inside a rolled down plastic bag and then placed in the bait pan. Periodically check the bait so that it does not become a breeding site for flies. The larvae feeding on the bait can crawl out of the plastic bag and away from the trap to pupate. If larvae are found in the bait, the plastic bag should be sealed, thrown away, and replaced with a new bag and bait.
- Sex pheromone baits for flies do not last long and do not attract flies from a distance. They are likely to be more expensive and less

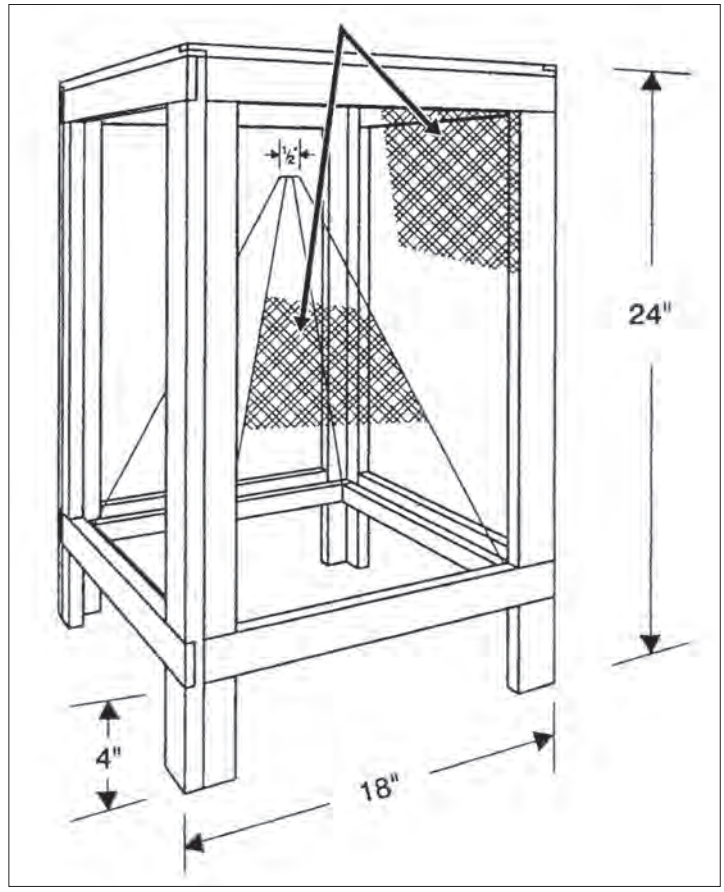

FIGURE 6.2. Cone trap diagram. A bait pan is placed beneath the cone. Make sure the top edge of the bait pan is above the bottom edge of the trap. The top is also made of screening and should be hinged (to empty the trap) and closed with a hook and eye. Weatherstripping or a strip of foam or cloth glued to all four sides of the underside of the lid will prevent flies from squeezing out.

effective than food baits that can be made with common materials and attract both sexes.

- Poisons are not needed in the bait. Flies are more attracted to the live flies in the trap than they are to dead ones. However, if fruit flies begin breeding in the trap, a granular bait insecticide should be added. Treatment utilizing an insecticide would require application by a certified pesticide applicator.
- The top edge of the bait pan must be at least ½ inch above the bottom edge of the trap. If flies can sit on the top edge of the bait pan and look out under the trap, trap catches will be poor.

Fly Bait Recipes

Bait is important to the performance of the trap. Here are some recipes and tips for using them.

Beltsville Bait

(from Pickens et al. 1994)

This makes a dry bait that can be easily stored for a considerable time. It must be mixed with water before using.

Ingredients

1 pound granulated sugar

1 pound baking powder (double-acting type)

2 ounces dry active yeast (baking yeast)

6 ounces air-dried blood or freeze-dried fish meal

¼ cup honey

2 tablespoons water*

*Quantity of water needed may vary with the humidity of air when mixing. Use only sufficient water to bind dry ingredients together when they are compressed.

Procedure

Mix ingredients thoroughly. Press mixture into a plastic ice cube tray to form cubes. Invert the tray to dump the cubes and let them dry to form hard blocks. To use the bait, add 2 cubes of bait to 2 quarts of water. Place bait in a wide-mouth pan beneath a cone-type trap. Flies are attracted to this bait from only a short distance, so traps should be placed within 6 feet of areas where flies are active. Bait pans should be cleaned and baited every 1 to 2 weeks and kept filled with water.

Liquid Yeast Bait

(from Satrom and Stephens 1979)

This recipe makes seven to nine portions of liquid bait for use with a cone trap. It can be stored for 20–30 days once it is ready for use.

Ingredients

2 quarts tepid (not hot) water (95–105°F)

1 cup and 3 ounces active dry yeast (baking yeast)

2 tablespoons ammonium carbonate (optional)*

*Ammonium carbonate is available from chemical supply houses and will improve the odor of the bait.

Mixing the Bait

Mix all the above ingredients in the jug. Use a plastic (not glass) narrow-necked gallon jug with a screw cap for mixing, ripening, and storing bait. Wide-mouth containers will not produce effective bait. Bleach or milk jugs work well. Be sure that any reused containers are properly cleaned prior to bait mixing, relabeled accordingly, and responsibly disposed of within the letter of federal, state, and local laws.
Note: With cap lightly sealed, allow mixture to begin to ripen (see ripening instructions below). It will foam up at first. After it subsides (one to two days), tighten the lid and continue ripening until very smelly (two to nine additional days). Gases must escape while bait is foaming up (loose cap), but bait must finish ripening without air (tight cap) to attract flies.

Ripening the Bait

Allow bait to ripen for four to ten days in a place where temperatures remain above 60°F during the night and day. Bait is ripe when it is very smelly, with a musky, penetrating odor. Warm daytime temperatures will make up for slightly cooler (below 60°F) nights, but in general, the warmer the average temperature, the faster the bait will ripen. Because of its heavy odor, the bait should be ripened in a well-ventilated area where it will not offend people. Do not ripen or store the bait in direct sunlight. Extreme temperatures can build within the jug, kill the yeast, and cause gases to expand enough to pop the lid off or break the jug.

Storing the Bait

To maintain potency, store bait with the cap kept tight. Open the jug only when necessary to refill the bait pan. Do not store in direct sunlight.
Note: Ripened bait should be treated as a decaying food material. It can cause gastrointestinal disturbances if ingested.

Using the Bait

Stir or shake the bait supply each time before adding to the bait pan. Pour about 1 cup (8 ounces) of bait in a wide pan on a level surface under the trap. Be sure the edge of the pan is higher than the bottom edge of the trap frame. The bait is effective in the pan for at least three to five days. It attracts more flies on the first day and then gradually declines thereafter. Don't let the bait dry out.

- Prevent excessive amounts of water from getting into the trap. If dead flies in the trap get wet and begin to rot, they may attract blow flies that will lay their eggs on the outside of the screen.
  - When the tiny blow fly larvae hatch, they crawl through the screen to feast on the rotting mass of flies. This turns the trap into a messy breeding site for flies.
  - Do not place traps where sprinklers will get them wet.
  - In areas where rainstorms are frequent, it may be necessary to fit the trap with a clear Plexiglas top.

Chemical Controls

Except for odor-eliminating chemicals and baits, pesticides are not recommended for fly management. However, where children do not have access to dumpsters, baits inside and residuals on the outsides of dumpsters work well. If borax is used as an insecticide or bait in combination with an insecticide, the treatment requires application by a certified pesticide applicator. Pesticides must be used in accordance with their EPA-approved label directions, including that it is labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and Safety Data Sheets (SDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label. **Pennsylvania law allows pesticide applications in schools and childcares only by certified applicators, registered technicians, or noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must be posted in an area of common access for applications made at or in a school building at least 72 hours prior to and for 48 hours after the application. For applications made on school grounds the sign must be posted at the place to be treated at least 72 hours prior to and for 48 hours after the application. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied in a school building or on school grounds where students are expected to be present for normal academic instruction or extracurricular activities.**

Borates

Low concentrations of borax in water can be used to eliminate fly odors. This solution is particularly effective for removing fly specks from walls and eaves and rinsing out garbage cans and dumpsters. These solutions should not be used near ponds, streams, lakes, or other bodies of water or poured onto plants.

IPM for Head Lice

INTRODUCTION

Few conditions seem to cause as much concern and anxiety in schools, childcares, and homes as an infestation of head lice in the hair of children. Many people associate head lice with filth, but in reality, these insects do not discriminate according to social class or level of personal hygiene. Lice are parasites of humans. Three types of lice can infest humans: head lice, body lice, and crab lice **(FIGURE 7.1).** This section deals primarily with *Pediculus humanus capitis*, the head louse.

CENTERS FOR DISEASE CONTROL AND PREVENTION

FIGURE 7.2. Size of nits compared to a penny.

IDENTIFICATION AND BIOLOGY

Head lice *(Pediculus humanus capitis)* are wingless insects measuring about ⅛ inch long. They are flat and gray-brown in color, with special mouth-parts for piercing and sucking. Their laterally positioned eyes are small, and the female is generally larger than the male. Adult lice have six legs with large tarsal claws, which enable them to cling to hair shafts of a host. Lice are unable to fly, jump, or leap from person to person, but adults and newly hatched nymphs can crawl rapidly from hair shaft to hair shaft. They live their entire life as an external human parasite. They do not survive for more than one or two days without a blood meal.

Lice eggs, called nits, are glued to hairs of the head near the scalp, especially near the ears and on the back of the head near the neck. A female can lay 8 to 10 eggs per day and a total of 50 to100 eggs during her life. Usually the nits hatch in 7 to 10 days, leaving behind empty shells attached to the hairs. Unhatched nits are clear in color; hatched or empty nits are milky in color, with a missing top **(FIGURE 7.2)**. The young lice must feed within 24 hours, or they die. It takes about a week to 12 days for lice to become adults. When lice feed on human blood, they inject their saliva into the host to prevent clotting. Meanwhile, they deposit fecal material onto the scalp. People previously unexposed to lice usually experience little irritation from their first bite. After a short time, some individuals become sensitized to the bite and experience a general allergic reaction, which may involve reddening of the skin, itching, and general inflammation.

Body lice *(Pediculus humanus corporis)* are practically indistinguishable from head lice. The following chief features distinguish them:

WIKIMEDIA COMMONS

FIGURE 7.1. Lice that parasitize humans: (A) head louse, (B) body louse, (C) pubic or crab louse.

- Body lice attach eggs to clothing fibers instead of hair.
- Adults and nymphs spend most of their time on clothing. They move to the skin to feed and are most numerous where clothing is in continuous close contact with the body, such as at the armpits and belt line.
- Clothing plays a greater role in the transmission of body lice. Body lice survive longer off the host (4–10 days) than head lice; eggs also survive longer off the host (up to 30 days).
- Body lice are unlikely to become permanently established on a host who maintains good personal hygiene, including regular changes to clean clothing.

Crab lice *(Phthirus pubis)* are shorter (about 1/16 inch long) than the other lice, oval in shape, and have greatly enlarged second and third pairs of legs with large claws. The following are other epidemiologic features:

- Crab lice mainly infest pubic hair; they occasionally infest other coarse hair, such as axilla, eyelashes, eyebrows, mustache, or beard.
- Eggs are always attached to hair.
- Clothing plays an extremely small role in transmission. When separated from the human host, crab lice die in less than 24 hours.
- Transmission is almost always sexual; on occasion, indirect transmission occurs from clothing, bedding, and towels.

LEGAL BASIS FOR CONTROL OF LICE

Title 28, Health and Safety, Chapter 27, Communicable and Noncommunicable Diseases, Sections 27.71 (11), § 27.71 (12), 27.72, and 27.73 is the legal basis for excluding and readmitting children to school in relation to specified diseases and infectious conditions.

§ 27.71 (11) specifically relates to *Pediculus humanus capitis* (head lice) and provides for exclusion from school of students (public, private, parochial, Sunday, or other school, college, or preschool) who have been diagnosed by a physician or are suspected by the school nurse of having pediculosis. Exclusion from school is for the period of time until the student is judged noninfectious by the school nurse or the child's physician.

§ 27.71 (12) requirements for body lice *(Pediculus humanus corporis)* are identical to the requirements for head lice. Pupils are excluded from attending school until judged noninfectious by the nurse in school or the child's physician.

§ 27.72 provides for exclusion from school of pupils showing symptoms judged noninfectious.

§ 27.73 provides for readmission to school if the nurse is satisfied that the live infestation is noncommunicable or when the child presents a certificate of noninfectiousness from a physician.

The Pennsylvania Department of Health's Regulations of Communicable and Non-Communicable Disease do not include *Phthirus pubis* (crab lice).

MANAGEMENT OPTIONS

When lice are discovered in a classroom, check only children that have had head-to-head contact with the infected student. Studies by the Pennsylvania Department of Health and the American Academy of Pediatrics show no benefit from screening all children. All members of the family of any child found with head lice should be checked for lice activity. Some school districts may still adopt a "no nit" policy and not allow students back into the classroom with any nits remaining on the hair. However, modern research and policy do not support a "no nit" policy. Note that exclusion does not mean that a student must be sent home early; they may be allowed to finish the school day. Exclusion may end immediately after the first treatment. Nits should be checked for at home on a daily basis for at least a week after treatment. Unless the problem is addressed at home, an infestation may recur. Because of increased insect resistance to prescription and nonprescription treatments, head lice have become more difficult to manage, leading to more pressure on schools and childcares to provide treatments. **However, schools and childcares should not be sprayed or treated with any pesticide in an attempt to control head lice. Shampoos or other treatments should not occur in a school or childcare.**

Nonchemical Controls

Classroom Treatments

- Vacuum furniture and floor rugs thoroughly. Discard the vacuum bag immediately.
- Clothing (coats, hats, and other items) can be isolated in individual plastic bags for each student.
- Dry clean or wash clothing in hot water and use a hot dryer setting to kill lice.

FIGURE 7.3. Nit comb.

Personal Treatments

- Because treatments do not kill 100 percent of the eggs, it is important to retreat within 7 to 10 days for control. It is important to thoroughly read and follow the directions on any product used to control lice.
- Nit combs are designed to remove lice and eggs from the hair and are very effective if used properly **(FIGURE 7.3)**.
- The use of oils such as olive oil and coconut oil has shown promise if left on the hair for at least 8 hours. Consult with the school nurse or local public health nurse for more information.

Chemical Controls

Chemicals should not be used within schools to control lice. Infestations result from personal contact or the sharing of infested articles such as combs, brushes, and hats. School nursing staff can educate parents about proper louse management in the home.

PREVENTION

Prevention is always better than a cure. Here are some suggestions that should help prevent an initial transfer of head lice from one child to another:

- Assign hooks for each student.
- Have students keep hats in coat sleeves or pockets rather than in piles on shelves or on the floor.
- Resting mats, towels, or pillows for younger children should be permanently assigned and kept separate while in use and in storage.
- Avoid sharing combs, brushes, and hats.

If an infestation should occur, several steps can help prevent a reoccurrence.

- All personal articles that have been in contact with the patient's head should be deloused. Normal laundering with hot, soapy water (125°F for 10 minutes) or dry cleaning will kill lice and nits on clothing, bed linens, and towels.
- Combs and brushes should be soaked for 10 minutes in a pan of very hot water.
- Car seats, furniture, and carpeting touched by infested individuals should be vacuumed. Discard the vacuum bag immediately.
- Avoid close contact with individuals known to be infested.
- Avoid letting others use your personal articles, particularly hats, combs, and scarves.
- Bathe and shampoo frequently with hot water and soap. Many lice are killed or dislodged in the process.

For more information about head lice, contact the Pennsylvania Department of Health, PO Box 90, Health and Welfare Building, Harrisburg, PA 17108; call 1-877-PAHEALTH (877-72-432584); or call your district health consultant. Information is also available on the Pennsylvania Department of Health's website at **www.health.state.pa.us** and the National Pediculosis Association website at **www.headlice.org**.

IPM for Mosquitoes

INTRODUCTION

Since the introduction of West Nile virus (and more recently Zika, dengue, and chikungunya viruses) into the United States, the public has a heightened awareness of the importance of mosquito control. The three most distinct and abundant mosquito groups are *Anopheles* (carrier of malaria), *Culex* (carrier of viral encephalitis viruses), and *Aedes* (carriers of yellow fever, chikungunya, Zika, dengue, and encephalitis viruses). Pennsylvania is home to many species of mosquitoes within and outside of these main groups. However, insect ranges are known to change with the climate; therefore, mosquito species' ranges may also be changing.

Not all species can become infected with and transmit pathogens to humans; thus, identifying and targeting the most important mosquito species are essential steps in any mosquito control program. At this time, West Nile virus is the most abundant mosquito-borne disease in Pennsylvania that infects humans. Although the majority of people who become infected with this virus show no symptoms, about 20 percent of infected people develop flulike symptoms and 1 percent develop serious symptoms, including swelling of the brain and spinal cord that sometimes results in death. West Nile virus is transmitted to humans primarily by *Culex* mosquitoes *(Culex pipiens* [northern house mosquito], *Culex restuans* [white dotted mosquito], and *Culex salinarius* [unbanded saltmarsh mosquito]), but West Nile virus has also been found in other mosquito genera as well *(Aedes albopictus* [Asian tiger mosquito], *Coquillettidia perturbans* [cattail mosquito], *Culiseta melanura* [blacktail mosquito], and *Aedes trivittatus* [no common name]).

Human cases of other mosquito-borne pathogens have been reported in Pennsylvania; however, these cases are often sporadic and associated with travel to other countries. Some of these pathogens to note are chikungunya, Zika, dengue, eastern equine encephalitis, and LaCrosse viruses, some of which are transmitted by *Aedes aegypti* (yellow fever mosquito). Although the Centers for Disease Control and Prevention (CDC) estimates that the range of *Aedes aegypti* could extend to southern Pennsylvania (see **www.cdc.gov/zika/vector/range.html**), the species has not been found in Pennsylvania since 2002.

Mosquitoes also transmit heartworm to dogs and cats, but this disease can be easily avoided by administering medications to pets. Mosquitoes in Pennsylvania also transmit eastern equine encephalitis to horses, but a vaccine is available. Consult a veterinarian for more information.

IDENTIFICATION AND BIOLOGY

After digesting a blood meal, female mosquitoes lay their eggs in standing water. This includes swamps, storm retention basins, culverts, ponds, lakes, and natural or artificial containers such as tree holes, hollow stumps, pots, cans, tires, untreated pools, outside toys, animal tracks, bird baths, plugged rain gutters, or anything that holds water. Some mosquitoes are found close to the habitat from which they hatched, but others are capable of flying many miles; thus, area-wide control may needed. Most mosquitoes of public health importance in Pennsylvania are *Culex* **(FIGURES 8.1**

PETE DEVRIES, 2006

FIGURE 8.1. *Culex pipiens* (northern house mosquito) adult.

JAMES GATHANY, CDC

FIGURE 8.2. *Culex* sp. larvae and pupae.

AND 8.2), followed by *Aedes* **(FIGURES 8.3, 8.4, AND 8.5)**, which are both less than ½ inch long as adults. During their life, mosquitoes pass through four distinct stages: egg, larva, pupa, and adult. **FIGURE 8.6** shows the stages and characteristics that can help distinguish the three distinct mosquito groups.

Eggs are deposited either individually (*Anopheles* and *Aedes*) or in groups called rafts (*Culex*) on the surface of water or on soil where flooding will produce puddles or pools. *Culex* and *Anopheles* eggs hatch within 48 hours, whereas *Aedes* eggs can hatch within 48 hours or lie dormant for several months.

Larvae are called wrigglers because of their motion in the water. The wrigglers feed on organic debris and microorganisms and breathe at the surface of the water through tubes. As they grow, the larvae molt four times and then progress to the pupal stage after the final molt. Depending on water conditions, larvae can develop into pupae after a few days or several weeks.

Pupae are sometimes called tumblers because of their defensive motion to escape predators. They are shaped somewhat like a comma and do not eat. Pupae breathe at the surface of the water through two tubes at the top of their body.

Adults emerge from the tumblers, and as long as water is available in their habitats, the population gradually increases through the summer. The entire life cycle varies from 4 to 30 days, depending on the species and environmental conditions. Adult females must have a blood meal before they can lay eggs. They use their elongated piercing-sucking mouthparts to penetrate the skin and ingest blood. In itself, the bite of the mosquito causes little harm, although itching and swelling in response to the mosquito saliva, which contains a substance that prevents blood clotting, may develop. The real harm can result from the mosquito potentially transmitting several pathogens that were mentioned in the introduction.

MONITORING

The objective in monitoring is to detect populations of mosquitoes while they are still small and then deploy a combination of appropriate controls. The following techniques will cover most of the basic aspects of mosquito monitoring and subsequent control. A sketch or plot plan of the school/childcare grounds is helpful for recording locations where management may be needed.

JAMES GATHANY, CDC

FIGURE 8.3. *Aedes albopictus* (Asian tiger mosquito) adult.

JAMES GATHANY, CDC

FIGURE 8.4. *Aedes aegypti* (yellow fever mosquito) adult.

NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES

FIGURE 8.5. *Aedes aegypti* larvae.

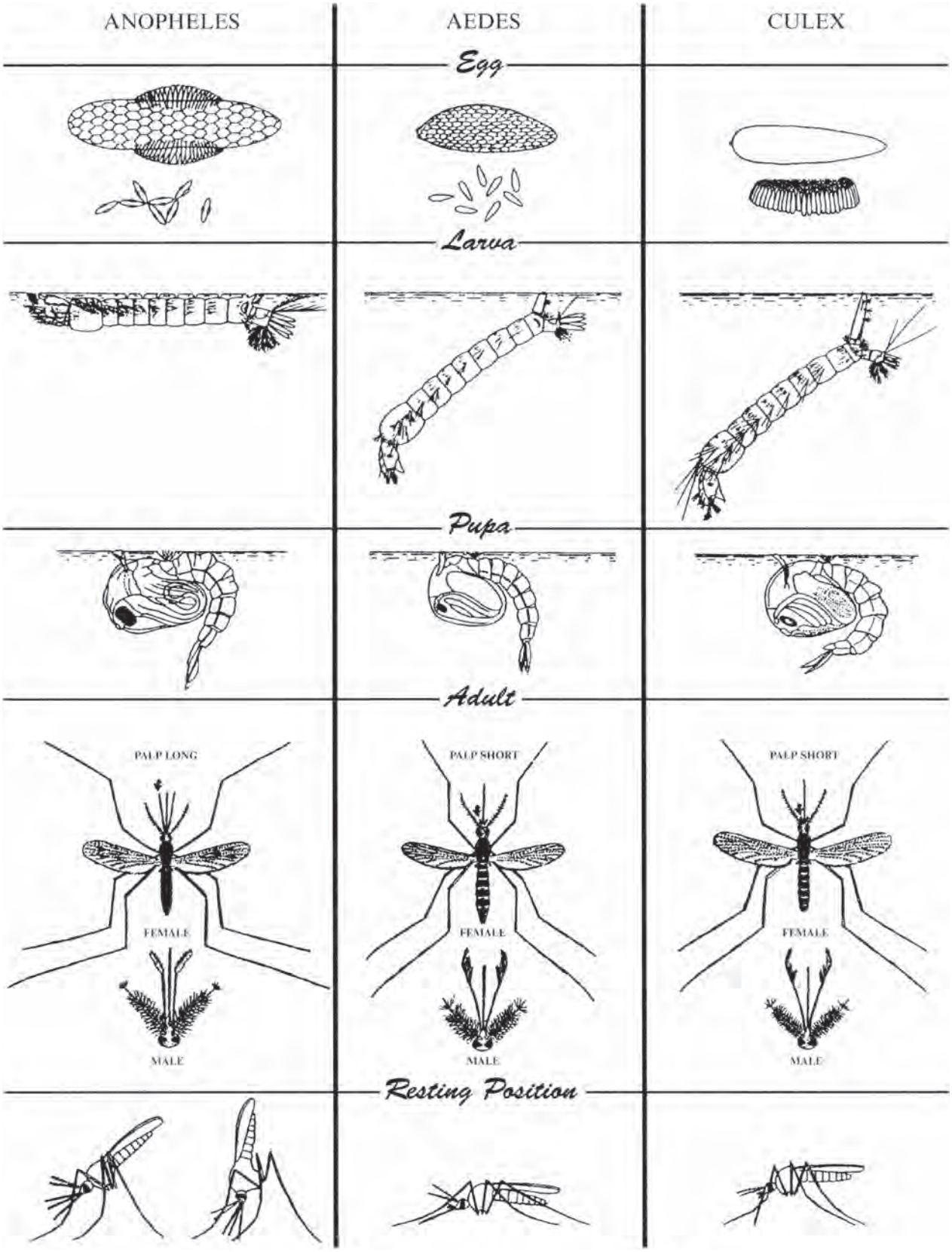

FIGURE 8.6. Characteristics of three groups of mosquitoes.

Larval Surveillance Methods and Equipment

Larval surveillance is an important aspect of an effective mosquito monitoring program. It can be used to determine the location, species, and population densities of pest and vector mosquitoes. It is vital for predicting adult emergence and establishing optimal times for application of larval control measures. It is used to forecast the need for adult mosquito control and to assess the effectiveness of both biological and chemical control measures. Basic tools required for larval surveillance include a standard, enameled, or plastic dipper about 4 inches in diameter (1-pint or 350-milliliter capacity) to take larval samples (the handle of the dipper may be lengthened by inserting a suitable piece of wood dowel or PVC pipe); a small pipette, eyedropper, or turkey baster; a pair of boots; vials, 6-ounce plastic bags, or some other container for storing larvae; labels for the collections; and a pen.

Mosquito larvae are found in a great variety of habitats. A number of different sampling techniques are needed to determine the presence or absence of immature mosquitoes and estimate their numbers. When searching for mosquito larvae, proceed slowly and carefully. Approach the area to be inspected with caution, as heavy footfalls will create vibrations that disturb larvae and cause them to dive to the bottom. Likewise, avoid disturbance of the water, as this will have the same result. Approach the area to be sampled with the sun in your face; this prevents shadows, which also disturb larvae and cause them to dive. If it is windy, dipping should be done on the windward side of the habitat where larvae and pupae will be most heavily concentrated. Mosquito larvae are usually found where surface vegetation or debris is present. In larger pools and ponds, they will usually be confined to the margins and will not be found in open, deep water. Dipping should be done around floating debris, aquatic and emergent vegetation, logs and tree stumps in the water, and grasses around the margins. Look for the presence of larvae and pupae before beginning to dip.

The type of mosquito larvae you are looking for, as well as the type of habitat you are working in, will determine the dipping technique used. Choose the most appropriate technique to obtain the most reliable results. The following seven techniques have been developed for sampling mosquito larvae and pupae with the standard pint dipper:

1. **The shallow skim.** Larvae are normally found at the surface of the water and among aquatic vegetation or floating debris. They can be collected with a shallow, skimming stroke along the surface, with one side of the dipper pressed just below the surface. End the stroke just before the dipper is filled to prevent overflowing. This technique targets *Anopheles* mosquitoes.
2. **Partial submersion.** Around emergent vegetation, logs, and tree stumps, larvae may be drawn into the dipper by submerging one edge so that the water flows rapidly into the dipper. In this method, the dipper is stationary within the water. This technique targets *Culex* and *Culiseta* mosquitoes.
3. **Complete submersion.** Specific larvae (such as species of *Aedes* and *Psorophora*) are very active and usually dive below the surface when disturbed. In this case, a quick plunge of the dipper below the surface of the water is required, bringing the dipper back up through the submerged larvae. Bring the dipper back up carefully to avoid losing the larvae with overflow current.
4. **Dipper as a background.** This is an especially useful technique in woodland pools for early season species. Submerge the dipper completely within the woodland pool, going down into the bottom litter if necessary. Use the white dipper as a background against which larvae and pupae can be spotted. Come up underneath the larvae with the dipper. Once again, bring the dipper up carefully to avoid losing its contents. This technique targets *Aedes* mosquitoes.
5. **Flow-in method.** This method is useful in situations where the water is shallow and mud, leaf litter, or other debris appears on the substrate. Specimens can be collected by pushing the dipper down into the material on the bottom and letting the shallow surface water and mosquito larvae flow directly into the dipper. This technique primarily targets *Aedes* but can also be used for *Culex*.
6. **Scraping.** This method is used in permanent or semipermanent habitats containing clumps of vegetation. Dip from the water in, toward the vegetation, and end by using the dipper to scrape up against the base of the vegetation to dislodge any larvae present. This technique targets *Coquillettidia* species.
7. **Simple scoop.** Frequently referred to as "the standard dipping procedure," this technique seems to be the one most commonly used by field personnel for larval surveillance. It involves simply scooping a dipperful of water out of a habitat. It is useful in a wide variety of habitats, especially for collecting *Culex*.

The basic information collected with each sample should be the following: date, location or site, type of habitat, climatic conditions, degree of cloud cover present, the larval or pupal density, stages present (larvae and/or pupae), and species (determined in the lab through identification). An average of five to seven larvae per dip may indicate the need to use a larvicide in the area.

Below is an approximate timeline to follow in a monitoring program:

1. **Mid-March:** First sample taken. Although this is still in the cold part of the spring and dip samples will most likely be negative, monitor anyway. This will allow you to pinpoint potential areas of activity later.
2. **April through June:** Monitor every two weeks.
3. **July through September:** This is the peak part of the season, so monitor weekly.
4. **October finishes mosquito season:** A sampling at this time can help access the effectiveness of the control program.

To identify the species of collected larvae and adults, samples can be submitted to the Pennsylvania Department of Environmental Protection. Call 717-346-8243 for information about how to submit samples.

MANAGEMENT OPTIONS

Habitat Modification

Eliminate Mosquito Breeding Sites

By eliminating mosquito breeding sites on school/childcare property, the number of mosquitoes can be reduced in the area.

- At least once a week, dispose of or flush anything outside that can hold water, such as tin cans, containers, pots, toys, bird baths, and particularly used tires, which have become the most important mosquito breeding sites in the country.
- Clean gutters and downspouts so they drain and do not contain leaf litter or standing water. Avoid the use of corrugated downspout extenders, which will retain enough water in the grooves to allow *Aedes* mosquitoes to breed. To prevent this issue, use smooth-sectioned materials instead or cover the open end of the downspout with a piece of fine mesh and an elastic band to prevent mosquitoes from entering the pipe.
- Drill holes in the bottoms of recycling containers left outdoors to allow rainwater to drain.
- Turn over wheelbarrows and other tools that may collect water when not in use.
- Do not allow water to become stagnant in bird baths, ornamental pools, or other outside areas.
- Empty accumulated water from any trailers.
- Keep dumpsters and trash receptacles covered to prevent water accumulation.
- Alter the landscaping to eliminate standing water. Keep in mind that during warm weather, mosquitoes can breed in any puddle of water that lasts for more than four days.

Eliminate Adult Resting Sites

Cut back or remove dense brush and other vegetation from around buildings. Keep grassy areas mowed. Promote natural breezes to discourage mosquito occurrence.

Biological Controls

Biocontrol is the use of biological organisms to control pests. Native predaceous fish have often proved effective for larval control; however, the use of nonnative fish is not allowed. Contact your West Nile virus county coordinator for more information on the efficacy of this method in your area and details about how to implement it (see **www.westnile.state.pa.us/contacts.htm**). Other biocontrol agents (such as bat houses, martin houses, and amphibian/reptile shelters) have been tested, but so far none have been operationally feasible.

Avoidance

- Reduce outdoor exposure during peak periods of mosquito activity during the season (April to October) on a daily basis. *Culex* mosquitoes tend to bite at dawn, dusk, and in the early evening; conversely, some *Aedes* mosquitoes bite during the day.
- Avoid areas where mosquitoes tend to concentrate, such as in tall grass, margins of wooded areas, or heavily wooded areas in dense vegetation.
- Avoid bites by minimizing exposed skin (i.e., wear long pants, closed-toe shoes, long-sleeve shirts). Note that some species of mosquitoes tend to preferentially bite ankles and feet.
- Avoid wearing dark colors. Mosquitoes and other biting flies are attracted to dark greens,

browns, and black. They are less attracted to light-colored clothing, especially whites and yellows.

- Make sure window and door screens are in good repair and there are no gaps where mosquitoes could enter the structure.

Chemical Controls

Pesticides must be used in accordance with their EPA-approved label directions, including that it is labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and Safety Data Sheets (SDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label. **Pennsylvania law allows pesticide applications in schools and childcares only by certified applicators, registered technicians, or noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must also be posted on school grounds at the place to be treated at least 72 hours prior to and for 48 hours after the application. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied on school grounds and students are expected to be in the immediate vicinity for normal academic instruction or extracurricular activities.**

Larvicides

In general, mosquito larvae control is more effective than spraying for adults. Applying pesticide treatments to water in Pennsylvania requires a pesticide applicator certification in Category 9 (Aquatic Pest Control) and/or 16 (Public Health Invertebrate Pest Control). For more information about becoming certified in these categories, visit the Pennsylvania Department of Agriculture Bureau of Plant Industry website at **www.paplants.pa.gov**. If making a pesticide application to a pond, lake, or waterway (something other than a lined, contained water feature), a joint permit from the Pennsylvania Department of Environmental Protection and the Pennsylvania Fish and Boat Commission is required (see **www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=3677**).

Several materials in various formulations are labeled for mosquito larviciding, including some biorational pesticides, fly-specific bacteria, insect growth regulators (IGRs), and chitin synthesis inhibitors. Also labeled for mosquito control are conventional insecticides, several nonpetroleum oils, and monomolecular film. The timing of larvicide application is dependent on the nature of the control agent. Conventional insecticides kill larvae at all stages and can be applied when convenient. Bacterial toxins, such as *Bacillus thuringiensis* (Bti), must be consumed by the larvae and are usually applied well before the fourth molt to ensure consumption. IGRs must be applied later in the development of the larvae to upset the molting process. Chitin synthesis inhibitors are effective throughout the entire larval life. Monomolecular films prevent the insect from remaining at the surface of the water by reducing surface tension, causing the larvae and pupae to die. Nonpetroleum oils kill larvae and pupae by suffocation.

Adulticides

The ground or aerial application of chemicals to kill adult mosquitoes is usually the least efficient mosquito control technique and considered the last resort when other methods have failed. Adulticides are often applied as ultra-low-volume sprays in which small amounts of insecticide are applied as spot treatments using backpack sprayers or dispersed either by truck-mounted equipment or from fixed-wing or rotary aircraft. The tiny droplets must contact the mosquitoes to be effective. These applications must be performed by certified contractors, which are usually dispatched by Pennsylvania's Mosquito Surveillance and Control Program on an as-needed basis. To find a listing of planned adulticide treatments for municipalities across the state each year, visit **www.westnile.state.pa.us/events.htm**.

Repellents

This section is specific to school personnel, maintenance staff, or other adults. Some repellents can be applied directly to the skin, whereas others can be used on clothing. Always read and follow label directions carefully and only use insect repellents that have been approved by the EPA, as indicated on the label. An effective skin-applied repellent will contain at least 20 percent DEET (N,N-diethyl-3-methyl-m-toluamide), such as Cutter Backwoods and Off! Deep Woods. Repellents with less than 20 percent DEET can be used, but the amount of time they provide protection is limited. Skin-applied repellents with DEET concentrations greater than 50 percent have no added benefits. Other insect repellents

shown to be effective include picaridin, IR3535, 2-undecanone, and oil of lemon eucalyptus. Note that other products are available, but their effectiveness is not known at this time. Various devices that can be worn, including bracelets and clips, are not effective (see *Journal of Insect Science* 17, no. 1 [January 2017]: 24, **doi .org/10.1093/jisesa/iew117**). Additionally, it may be necessary for personnel to wear sunscreen and repellent in certain situations. Sunscreen should be applied first and allowed to dry, followed by application of a repellent with one of the active ingredients described above. Products that combine sunscreen and repellent are not recommended. For more information about using insect repellents safely, see **extension.psu .edu/using-insect-and-tick-repellents-safely**.

Questionable Control Methods

Many devices are being sold to control mosquitoes, but not all are effective. For example, outdoor insect light traps (bug zappers), citrosa plants, and others are generally ineffective at controlling mosquitoes. Even bats and purple martins have been shown to be no more effective than bug zappers in mosquito control, as both are opportunistic feeders and will feed on any insects available rather than specialize on mosquitoes. Mosquito control methods that have been rigorously tested are preferable to maximize efficacy and minimize cost.

IPM for Rodents

INTRODUCTION

Rats and mice often enter schools and warehouses in search of food and shelter. The most common rodent pests are the commensal rats and mice. They are a serious threat to health and safety and must be controlled. Rodents are the most significant asthma trigger present in schools. Mouse allergens were found in over 90 percent of schools surveyed, at levels up to 600 times higher than found in homes. They also serve as reservoirs or vectors of numerous diseases, such as rat bite fever, leptospirosis (Weil's disease), murine and typhus, and outbreaks of foodborne illness associated with *Salmonella, C. perfringens,* and *Shigella*. Rodents chewing on wires may damage vehicles and electrical and data systems and start fires. Mice are mostly an indoor problem, while rats tend to be an outdoor problem.

"Commensal" means they "eat at our table." They are Old World rodents that have adapted to live with humans. It has been suggested that a more accurate characterization would be "kleptoparasitic," meaning they steal what they need—food and nesting material—from us. Commensal rodents include the Norway rat, the house mouse, and the roof rat (which does not usually occur in Pennsylvania). These commensal rodents have been carried by humans to every corner of the Earth. Rats and mice consume or contaminate large quantities of food (about 20 percent of the world's food supply) and damage structures, stored clothing, and documents.

Many schools feed students breakfast and sometimes other meals in the classrooms rather than in a cafeteria. This is challenging to pest control because it creates food waste throughout the school. No matter how careful students and staff are, rodents (and insects) will exploit the litter, crumbs, and spills that are available. All meal waste must be carefully bagged and removed from classrooms as quickly as possible; no trash or recycling should remain in the rooms overnight.

In most cases of rodent infestation, the pest animals can be managed without having to resort to the use of poisons. The U.S. Environmental Protection Agency (EPA), the U.S. Centers for Disease Control and Prevention (CDC), the U.S. Department of Housing and Urban Development (HUD), and the National Pest Management Association (NPMA) recommend against the use of rodenticides (pesticides that kill rodents, usually in bait form) in child-accessible areas. Practicing good sanitation and exclusion will prevent most problems. If rodents do find their way indoors, small populations can easily be eliminated with various nontoxic methods. Rodenticides need only be used in cases of large or inaccessible infestations. Trapping rodent pests is usually preferable to using rodenticides. Traps prevent rodents from dying in inaccessible places and causing odor and additional pest problems. Traps can also be used in situations where baits are not allowed.

IDENTIFICATION AND BIOLOGY

Mice

The house mouse *(Mus musculus* or *Mus domesticus)* is the most common commensal rodent that invades schools **(FIGURE 9.1)**. It is primarily nocturnal and secretive. The incidence of mice is usually indicated by sightings, the presence of droppings, or damage caused by gnawing into food containers. In the wild, house mice feed primarily on seeds. In a school, they prefer grain products, bird seed, and dry pet food, as well as snacks left in desks, lockers, or lounges. They tend to nibble on many small meals each night. House mice are inquisitive and actively explore anything new. They are also good climbers. However, they have a small home range and usually stay within 10–30 feet (3–10 meters) of their nests, which are usually are built in structural voids, undisturbed stored products or debris, or outdoor burrows. Mice are very cautious about moving in the open. They would rather run behind an object or along the baseboard of a wall than across an open space.

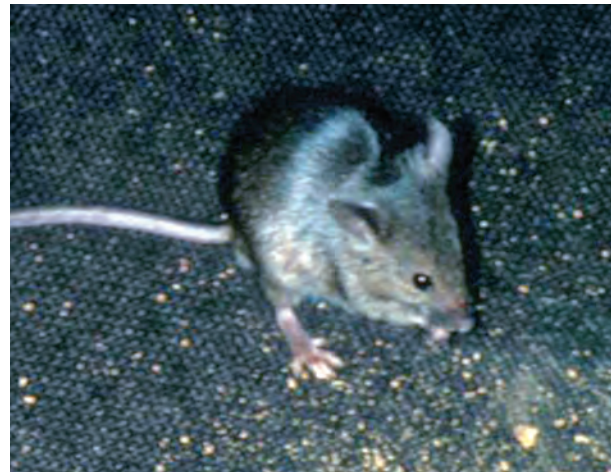

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FIGURE 9.1. House mouse.

House mice can reach sexual maturity in 30–60 days and have a 21-day gestation period. One pair of mice can produce over 700 descendants in one year. Mice only need to eat 1/10 ounce (3 grams) of food per day, and they do not need a constant source of fresh water because they can harvest water from the food they eat. Indoors, mice live in nests that are usually inside walls, in motor compartments, above suspended ceilings, and in other voids. They prefer dark, seldom disturbed areas; these are the best places to look for holes. Mouse holes are not "train tunnel" shaped; instead, they are typically ovals that are low and small (as little as ¼ inch high), either round or flattened, and become wider as the mice continue to gnaw. They may also use gaps in baseboards or wall penetrations for utilities or radiators to access wall voids. Once inside the walls, the mice use the horizontal and vertical lines of plumbing, ducting, cables, etc., to move and access other areas of a building. Ceiling plenums are excellent habitat, giving ready access to all areas below. Irregular stains on ceiling tiles (in contrast to round water drip stains) may indicate the presence of a nest above. Nests are cantaloupe-sized balls of fluff composed of shredded fabric or paper.

The range of a mouse is usually less than 30 feet (10 meters), but that is 30 feet in all directions. Mice are excellent climbers; they are able to scale any rough surface and jump amazing distances of 12–18 inches (25–37 centimeters) from a standstill and up to 4 feet (1.25 meters) with a running start. Mice are cryptic and seldom seen; even when an actual mouse is sighted, the mouse is usually running and the impression left is "was that a mouse?!" Mice in schools will usually be active after human activity ceases. Of course, in very heavy infestations mice may be seen anytime. Seeing mice in daytime usually indicates a heavy infestation.

Mice are the biggest asthma trigger in the school environment. The most common indicator that mice are present is their feces (i.e., droppings). The allergen *Mus 1* is expressed in mouse urine; mice urinate as they are moving about, dribbling thousands of microdrops along their path as seen by their droppings. This creates an invisible line of allergen connecting the pellets, usually around the edge of the room and along the wall. If the room has wall-to-wall carpeting, the edge will become an allergen-saturated sponge, constantly emitting the allergen, which is persistent for six months. Carpets, often found in lower-grade classrooms, libraries or instructional media centers, hallways, auditoriums, and other areas, should be removed if possible. Area rugs may be used, especially in preschool or kindergarten rooms; however, they should not touch the walls and should regularly be removed for cleaning.

Mice will also leave stains on walls by their holes and in other regular runways. These are caused by the oils in their fur as they run along the wall. Mice prefer to keep at least one side against the wall; they rest and eat in corners, where they feel even more protection. Dark staining indicates frequent use.

Rats

Rats are productive breeders, becoming sexually mature in less than three months with a litter of 6 to 12 pups born after 25 days of gestation. They average four litters a year or about 30 pups per female. Rats eat about 2.5 ounces (71 grams) of food per day and require a source of fresh water. They typically live outdoors in burrows and will enter buildings in search of food. Rats may move into seldom-used storage spaces, outdoor sheds, or similar rooms. Rats may also enter plenums or voids above suspended ceilings. Burrows may be dug or structural. Dug burrows have a main entrance and at least one well-camouflaged bolt hole. Burrow systems may become very large and threaten to undermine sidewalks, fences, sheds, dumpster pads, etc. Structural burrows incorporate human-created structures, such as under sidewalks or staircases. Rats have large home ranges and may travel more than 50 yards to reach food or water.

The rats that occupy buildings and sewers in Pennsylvania are generally **Norway rats** (*Rattus norvegicus*), which are often called by other names, including the brown, wharf, or sewer rat **(FIGURE 9.2)**. These rats are strong burrowers, but they can also climb well. They are excellent swimmers and can swim underwater for up to 30 seconds. They can enter buildings by coming up through toilet pipes. These rats usually dig burrows along building foundations and under debris piles. They

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FIGURE 9.2. Norway rat.

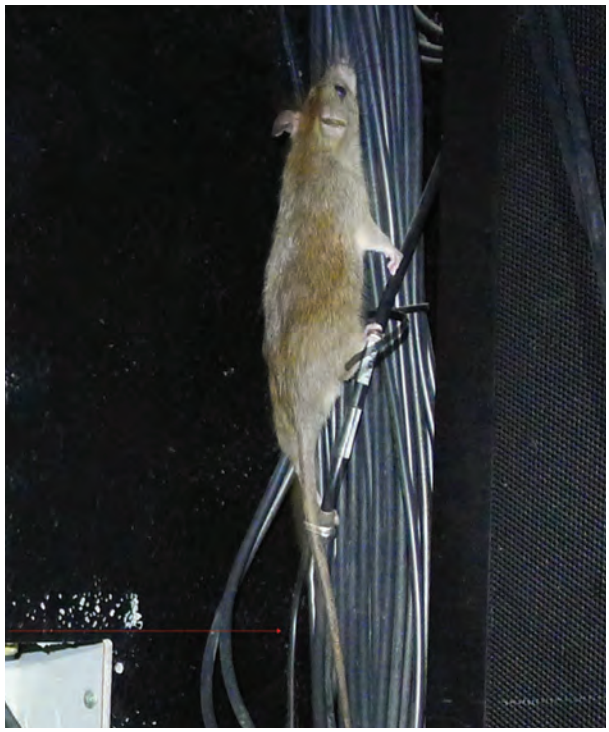

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FIGURE 9.3. Roof rat climbing wires.

have a strong preference for meat and fish but will do well on any type of human or pet food.

The **roof rat** or **black rat** (*Rattus rattus*) is more commonly encountered in buildings in southern states but is sometimes found in Pennsylvania **(FIGURE 9.3)**. These rats are excellent climbers and often nest in attics, wall voids, and hollow trees. They prefer to travel off the ground and enter houses from nearby trees or along power lines. Roof rats prefer fruit but will eat any type of human, pet, or livestock food. The presence of roof rats can be determined by gnawing damage; the presence of droppings; sightings; sounds of scratching, squeaking, or gnawing in walls or ceilings; and dark, greasy rub marks on pathways along walls and on rafters. The Norway rat is very aggressive and will drive roof rats out of an area. However, both species of rats may be found in the same building, with roof rats in the attic and Norway rats in the basement.

INSPECTION

Indoor inspections for mice should begin with doors and windows to ensure they are intact and tightly sealed. Daylight should not be visible around or under a door. Air leaking out of the building is warm and carries the odors from the building, creating a plume that draws rodents right to the opening. Doors should not be left open. If ventilation is needed, install a screen door.

Look for dark, secluded areas because those are the most likely areas to find mouse holes or nests. Look for feces, rub marks, and signs of gnawing **(FIGURE 9.4)**. Inspect utility penetrations as they emerge from walls and check that pipes have escutcheons. Examine the inside of openings on outside walls (e.g., where outside lights are mounted on the wall) to determine if mice or

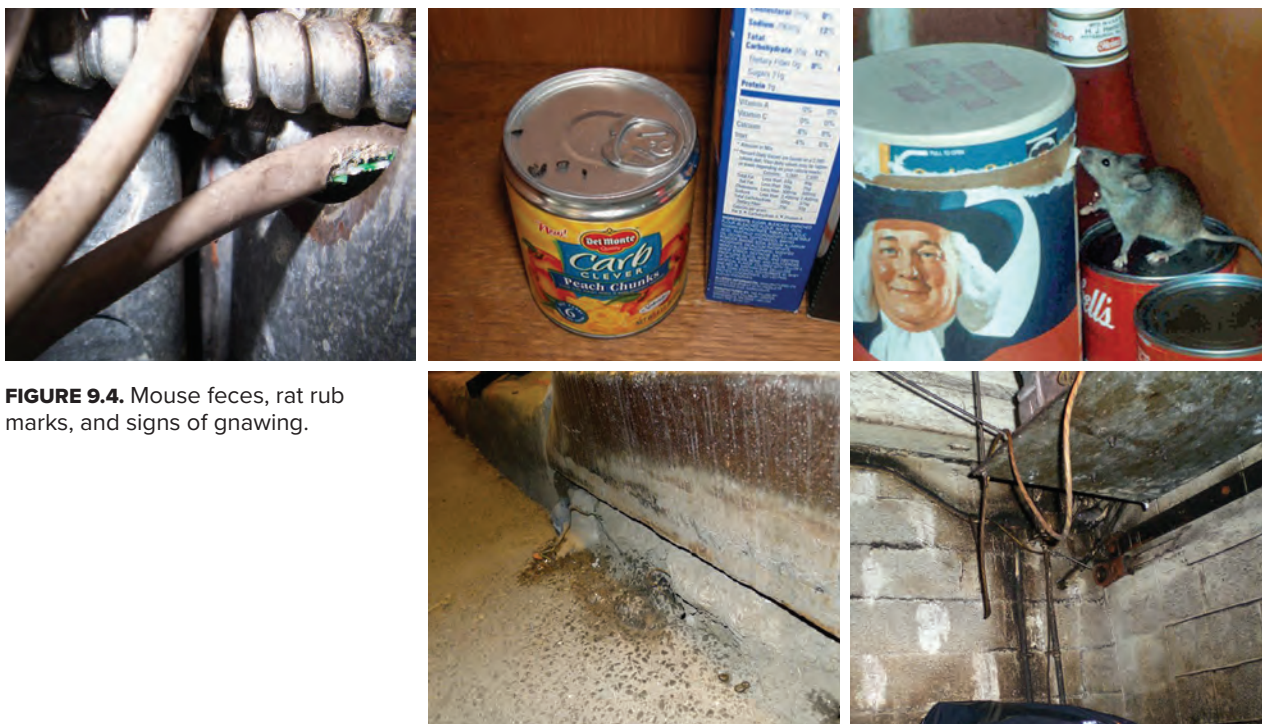

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FIGURE 9.4. Mouse feces, rat rub marks, and signs of gnawing.

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FIGURE 9.5. Rat feces.

insects are entering the building there. Inspect pest-vulnerable areas carefully, especially food prep, storage, and waste/recycle areas. If a building is heavily infested, visit every room, photograph findings, and keep notes.

Outdoor inspections for rats should begin along the foundation and move out systematically, examining the grounds for burrows, especially near waste storage areas, trash cans, picnic and smoking areas, and other areas where people consume food and create litter. Examine storage areas, woodpiles, etc., and eliminate debris that could obscure burrows. Carefully inspect groundcover, such as ivy or pachysandra, and ornamental bushes that reach the ground, which also provide harborage and obscure burrows and trails. If burrows are located, mark their locations and contact your pest management professional for treatment.

Next, move indoors, starting in the basement and moving upward while checking for openings or penetrations. These should be noted on a plan of the building and repaired. This "exclusion," also called "rodent-proofing," is discussed below. Pay special attention to corners and isolated or dark areas. Rat feces are a clear sign of rodent presence; they are lumpy, up to ¾ inch (2 centimeters) long, and will contain visible hair from grooming **(FIGURE 9.5)**. Large accumulations may be found, as some rats practice "latrine behavior" and consistently defecate in the same place. Many other animals, including cats and raccoons, also practice latrine behavior, which creates a concentrated health risk. Urine stains may also be observed or smelled. These areas are biohazards; see instructions from the CDC on page 105 for cleaning rodent feces.

Rats will often use plumbing, electrical, or data chases and follow ventilation systems to establish pathways. Regular runways will be marked by "rub marks," which are dark stains on surfaces caused by oils (sebum) from the rodent fur. Look for signs of gnawing around entry holes or along runways. If an area is a suspected runway, talcum powder can be sprinkled along the edge of the wall, pipe, duct, etc., and then inspected several days later to deduct a pathway or frequently traveled routes. Tracks are diagnostic: tracks measuring ¾ inch (19 millimeters) long or less will be mice, while tracks measuring at least ¾ inch (19 millimeters) or longer will be rats.

The EPA's Indoor Air Quality Tools for Schools Program has a downloadable inspection checklist app that is available for mobile devices. See **www.epa.gov/iaq-schools/indoor-air-quality-tools-schools-action-kit**.

MANAGEMENT OPTIONS

Habitat Modification

Sanitation

Sanitation is the most important part of rodent control and a key factor in inspection. All animals have three requirements for life: food, water, and shelter. Removing any one of these will force an animal to leave.

Mice eat very small amounts of food (1/10 ounce or 3 grams a day) in tiny bites. A mouse may eat 30 different foods to get that tenth of an ounce. They literally live on crumbs. Grease is a favorite high-energy food. Residue on candy wrappers in a waste basket can be food. Sanitation is critical. All food waste, recycling, compost, and trash must be removed daily. Food prep and storage areas must be swept and mopped daily. All storage should be at least 6 inches (15 centimeters) off the floor to facilitate cleaning, inspection, and control. Cardboard packing should be recycled; food in cardboard boxes or paper (e.g., oatmeal, flour, ready box mixes) may be stored in plastic food storage boxes with tight-fitting lids.

Rats require about 2.5 ounces (70 grams) of food and about 2 ounces (60 grams) of fresh water daily. This is a fair bit more food compared to mice, which can subsist on crumbs. A rat problem is always a sanitation problem. If the food source is removed, the rats will have to leave. Food service and waste storage areas are the obvious target pest vulnerable areas, but other areas, including any that house animals, may be attractive to rats. Rats will eat animal feces in addition to animal food. Athletic concession stands and similar structures are very vulnerable. These areas should be swept and mopped daily, and all waste should be removed at the end of each day.

Deep-cleaning (under and behind equipment, walls, and ceilings, etc.) should be performed periodically (e.g., quarterly). Food should be stored in rodent-proof containers. Practice FIFO (first in, first out) inventory rotation to keep stock moving and avoid "dead" storage areas that rodents can exploit. Rats require a daily source of fresh water; therefore, pipes and sinks must not leak, and water should not be allowed to stand overnight. Grease traps and filters must be maintained as scheduled (grease is a favorite food for all pests). Floor drains must be kept clean and have appropriate grates to exclude rodents. All equipment in food production or storage areas should conform to NSF, UL, or CE sanitary construction standards, including sealing all voids to exclude rodents. However, motor and condenser areas should always be inspected for rodent activity—being warm and isolated, these are favorite nesting areas for mice. Check above drop ceilings, reduce clutter, and keep baseboards and closet floors clear.

Decluttering classrooms and storage will substantially reduce the harborages for rodent pests. Stacked firewood and other similar materials stored for long periods of time provide good harborage for all three commensal rodents. Removing debris such as piles of trash, lumber, and abandoned large appliances will substantially reduce the harborages for rats. Trim trees, vines, bushes, grass, and weeds at least 12 to 18 inches from all buildings to decrease cover for rodent runways and prevent hidden access to buildings. Be sure to store pet food and seeds, such as wild bird seed, in rodent-proof glass or metal containers to eliminate rodent access to these food sources. Collect and remove fallen fruit from trees on school/childcare grounds. Keep lids on trash cans and close dumpsters at night to make an area less attractive to rats and mice. The drainage holes in dumpsters should be covered with hardware cloth to keep rodents out.

Exclusion

Exclusion (rodent-proofing) involves making your structure a fortress that rodents cannot breach. Vegetation and mulch should be removed along all building foundations from a strip of at least 12 inches (25 centimeters) wide. A 4-inch-deep trench, lined with landscape fabric to exclude weeds, should be filled with pea gravel (small, round gravel) that rodents cannot burrow through. Recent research has shown that sharp stones 2 inches in diameter in an 18- to 24-inch-wide belt are more effective at deterring rats. These tactics eliminate cover that rodents use to hide their movements and burrows.

Rodents can squeeze through any opening that their head can fit through. An opening larger than a dime (¾ inch,17 millimeters) can admit mice, and an opening the size of a quarter (1 inch, 26 millimeters) can give access to rats. Mice are small and flexible, which makes exclusion very important—and difficult. Young mice and rats are the dispersing individuals, so these are the ones most likely to invade new areas, like schools and childcares. Any door with a gap at the bottom that a pencil can fit through (¼ inch, 7 millimeters) will admit a mouse. Doors should be fitted with door sweeps; the brush style is usually more effective than thin rubber blades, but commercial-grade rubber door sweeps are the best application. These should be on **all** exterior doors, plus doors to food service and storage areas, mechanical rooms, trash handling rooms, and other similar rooms. Penetrations for utilities and so forth may be fitted with escutcheons or filled with other materials such as copper mesh or Xcluder® (a proprietary product made from shredded stainless steel and rubber). Damaged or missing building materials, such as missing mortar, damaged stucco, and damaged door or window frames, should be repaired. Window screens should be intact and in good repair. Air intakes may be screened with ¼-inch (6-millimeter) galvanized hardware cloth (mesh), which will exclude mice and rats. The mesh should be inspected annually for rust or damage. Ensure that eves and soffits are intact with no openings that rodents, birds, or other pests can exploit to enter the building structure.

Rodents follow horizontal and vertical lines, specifically plumbing, electrical or data chases, and ventilation systems, and may dig alongside sewer lines to gain access to buildings. All internal penetrations should be sealed, especially where plumbing emerges from walls, including radiator or uninvent pipes. If new services have been installed (e.g., technology upgrades requiring electrical and wiring upgrades), ensure all the chases are properly

sealed or fire-stopped (see the information on sealants on pages 43–44). Rats will require high-quality stoppage—sheet metal, Xcluder® products, or patching concrete may be necessary.

Extensive and persistent rodent burrows outdoors can be controlled using GEO mesh, a proprietary Xcluder® product. This stainless steel barrier is buried under 4 inches of soil, similar to weed-blocking landscape fabric. It completely eliminates the ability of rodents to burrow or penetrate the mesh; however, it is expensive, limiting its use to areas with high visibility and sensitivity.

Mechanical/Physical Controls

Traps

Rats usually fear new items in their environment and avoid them for several days. This means traps should be left in place for at least one week before they are moved to a new location. Concentrating traps along rat runways or favorite routes of travel is most effective. Traps may be prebaited—that is, baited but not set, allowing the rats to feed and become accustomed to the trap. Raw or cooked meat and fish, especially sardines, are excellent baits, but peanut butter also works well. (**Note:** Many school districts have no-peanut policies because of food allergies. Any food the rodents are eating may be used as bait.) After the bait has been taken, the traps can be rebaited and set. Note that traps do not use any poison or require a pesticide applicator license to place. Properly trained staff may maintain an in-house rodent control program.

There are four main types of rodent traps: snap traps, multicatch traps (for mice only), single-catch live traps, and glue boards. Some other devices are also discussed below.

Snap Traps

Snap traps include both the classic rodent traps with the wood base and newer designs such as squeeze-to-set. They are devised to kill the trapped animal quickly and humanely. Snap traps should not be set where children or pets will come in contact with them. They may be placed inside boxes or covers to protect them and make them inconspicuous. They have several different types of triggers; all have been shown to be effective. However, the expanded trigger is the most versatile since it can also be baited. Older snap traps with other types of triggers can be modified to produce an expanded trigger. The newer squeeze-to-set-style traps are much easier to use and very effective. They usually have tie-down slots, preventing trap movement, and may have removable bait cups, facilitating easier baiting and cleaning. See **FIGURE 9.6** for some examples of snap traps.

Snap traps are very effective and available in many styles and price points. Traps should be placed where rodents are likely to be and in their possible known pathways. Rodents are creatures of habit and prefer to follow the same runways they typically use. Mice and the Norway rat often run along edges, so traps should be set along walls, especially where objects such as a box or appliance will guide them into the trap. Roof rats prefer to travel above the ground and are easier to trap along these precarious pathways than on the ground. It is important to identify these runways and place traps in their paths. Runways can be identified by sprinkling a fine layer of baby powder in suspected areas and looking for tracks. This is a safe diagnostic method for determining rodent activity, but it should not be confused with the use of rodenticide tracking powders (which may be applied only into wall voids, not open surfaces), which are very toxic, require a certified pesticide applicator license to apply, and in general are not appropriate for a school or childcare environment. The traps should be placed no closer than 18 inches (45 centimeters) to each other. When the trap snaps, the discharged energy causes it to

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FIGURE 9.6. Snap traps.

spin (like a car in a crash). If it is too close to other traps, they will also be triggered, allowing the mice to get the bait and not be caught. Always place the trigger end against the wall; in narrow places behind equipment, place two traps back to back, with their triggers facing out.

The type of bait used depends on whatever they have been feeding on—that is their preference. Peanut butter or gumdrops stuck to the trigger or rolled oats or bird seed sprinkled on the trap are good baits for house mice. Protein (bacon, hot dog, etc.) may be secured to traps. Chocolate syrup may be dabbed on triggers. When food is abundant, nesting material, such as a cotton ball or yarn scraps, tied to the trigger can act as an effective lure.

Many new devices are being marketed that allow the mouse to get in but not out. Some traps are disposable and intended for a single use, while other professional devices may use traps and/or poison and a sophisticated knowledge of mouse behavior to lure the rodent.

Single-Catch Live Traps

These are rodent-sized cage traps of various styles. Live rat traps are seldom used because rats are very trap shy. Larger traps are more frequently used to trap squirrels, raccoons, skunks, opossums, etc. However, these are wildlife, not pest, species, and unlicensed staff or pest control operators may not act against wildlife. Wildlife needs to be removed by a Nuisance Wildlife Control Operator. If you have any questions or concerns about wildlife and its removal, contact the Pennsylvania Game Commission at 717-783-6527.

Single-catch live traps capture the rat or other pest alive and unharmed, but you then have to deal with the captured animal. Captives should not be released because they will return to buildings, and it is illegal to relocate them to parks or other areas. Animals caught in these traps must be killed humanely.

Multicatch Traps

Multicatch traps are designed to repeatedly catch mice and reset themselves for another capture. These traps have the ability to capture several mice with one setting, and the scent from the captured mice entices others to the trap. The traps are frequently used in food prep and storage areas and mechanical rooms. They are not usually used in classrooms or other public areas. Note that the captured mice may still be alive and must be dealt with efficiently. Methods of dealing with captive rodents include submerging the entire trap in a bucket of water and drowning them, using drowning attachments available for some traps, placing glue boards in the holding compartment of the trap, or finding someone with a pet snake that eats mice. Releasing captured rodents outside is not a solution because they will quickly find a way back into the structure. Trap-wise rodents are also more difficult to trap than naive ones. Like any other trap, multicatch traps must be checked regularly to prevent the captured rodents from starving or dying of thirst and creating an odor problem. Available multicatch traps include the Kness Ketch-All Automatic Mouse Trap, the Victor Tin Cat Repeating Mouse Trap, and the Mini-Mouser Mousetrap.

Glue Boards

Glue boards are used just like snap traps. While both rat- and mouse-sized glue boards are made, these traps are most effective against juvenile mice. Glue boards that fold into a box or tent shape are more effective than flat boards, as mice like to run into safe-appearing havens. Cardboard glue boards may be rolled and inserted into tubes, such as 18-inch (45-centimeter) lengths of 2-inch (5-centimeter) PVC pipe, which are then placed along walls, behind equipment, and so forth. Simply shake the tube over a garbage can to remove a trap that has caught a mouse, insert a new board, and replace the tube. Glue boards should not be set in wet or dusty areas because these conditions render the traps ineffective. Wet feet and fur will not stick to the glue, and dust coats the glue until it is no longer sticky. These traps should also not be set where children or pets will come in contact with them. Glue boards are not hazardous to children or pets, but an encounter will create a frustrating mess. If that happens, clean up hands with room-temperature cooking oil or Vaseline™ and clean surfaces with paint thinner or mineral spirits. Do not set glue boards near open flames or above carpets. Glue boards should be secured with a tack or small nail, wire, or double-sided tape if they are placed on ledges, pipes, or rafters.

Glue boards and other live traps should not be used in areas where Hanta virus has been identified. The feces produced by trapped mice greatly increases the risk of exposure to the virus.

Glue boards are not generally effective for rats because the rats are often strong enough to pull themselves free from glue boards. If used, choose a large, plastic, tray-type board with a thick layer of glue and secure the board with tack, wire, or cable ties to prevent it from being dislodged. Boards should be placed on active runways, adjacent to entry holes.

Electronic Traps

Electronic traps are battery powered and reported to be very effective. However, they are expensive, and batteries require frequent replacement, increasing cost and maintenance. New Internet-enabled rodent control devices are being developed that allow pest control contractors to get real-time information. While this is important for critical locations, such as food distribution centers or airplanes, it is probably unnecessary in most schools and childcares.

Ultrasound Devices

The principle behind ultrasonic devices is to create a loud noise above the range of human hearing (above 18 to 20 kHz) that is unpleasant to pest species. The problems with ultrasound devices are numerous. Animals can adapt to most situations, and in a short duration of time they become accustomed to the sound. If the original attractant (e.g., food) is still present, the rodents will return. The short wavelengths of ultrasound are easily disrupted, creating sound shadows. The rodents simply shift their activity to these low-noise shadows. Ultrasonic devices will not drive rodents from structures if food, water, and shelter are available.

Chemical Controls

Rodenticides

Rodenticides are pesticides that kill rodents. Rodents are mammals; humans are also mammals. Anything that can kill a rodent can also kill or harm a human. Children are especially vulnerable, and they may be affected by a much lower dose than adults. Rodenticides are seldom necessary to treat mice in schools and childcares. Pennsylvania guidelines prohibit the use of rodenticides in child-accessible areas, such as classrooms, cafeterias, locker rooms, and so forth. They may be used in storage and mechanical areas, service structures, etc. However, pesticides must be used in accordance with their EPA-approved label directions, including that it is labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and Safety Data Sheets (SDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label. **Pennsylvania law allows pesticide applications in schools and childcares only by certified applicators, registered technicians, or noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must also be posted in an area of common access at least 72 hours prior to and for 48 hours after the application of a pesticide in a school building. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied in a school building where students are expected to be present for normal academic instruction or extracurricular activities.**

If deemed necessary by a licensed pesticide applicator, rodenticides should be deployed when the school or childcare is on break to allow time for the rodenticide to be effective and to eliminate the risk of possible contact by students and staff with poisons or dead rodents. There are three main types of rodenticides: first-generation anticoagulants, second-generation anticoagulants, and nonanticoagulants. All rodenticides must be in secured in child- and animal-resistant enclosures. Baits are available in a number of formulations, including solid blocks, soft forms (like gummy candy), pellets, treated seeds, and even liquids. However, they may not be used loose in schools, childcares, or residences. Rodents will translocate bait and move it to their burrows or nests as a food source. This may result in rodenticides in unexpected locations. Nontoxic bait blocks are available for rodent monitoring. Some include a fluorescent tracer that is excreted in the feces, making it possible to prove feeding and even trace rodent pathways. Professional knowledge will guide product choice (see professional literature, including Corrigan's *Rodent Control*).

First-generation anticoagulants require multiple feedings to be effective. They cause rodents to hemorrhage internally in several days, depending on the dose consumed. Widespread resistance to these products has been documented. Second-generation anticoagulants only require one feeding to kill, but time to death is dose dependent, from a few days to a couple of weeks. They are very high risk to nontarget species, including children.

Nonanticoagulants vary in their action. Zinc phosphide pellets may be used in burrows outdoors but not within 100 feet (30 meters) of an occupied building because they liberate a highly toxic gas. Bromethalin has a unique mode of action that affects the cellular energy production cycle. Cholecalciferol is a form of vitamin D that causes blood vessels to calcify and disrupts kidney

function in rodents. It is the only rodenticide approved for certified organic facilities, but it is highly toxic to cats and dogs. Other acute pesticides (strychnine, red squill, etc.) are no longer used, especially on school or childcare grounds.

Rat Ice

In 2017 the EPA registered dry ice (frozen carbon dioxide, CO_2) for use as a fumigant for outdoor rat burrows by licensed pest control applicators **only**. All the burrow entrances must be located, and dry ice pellets are poured into each opening, which are then plugged. The rats suffocate as the pellets sublimate (turn from a solid to a gas, with no liquid state); the gas is absorbed by the ground. The rats are entombed in their burrows. While the dry ice is nontoxic to humans in use, it has serious safety issues involving handling and transport. Dry ice is very cold (-110°F, -79°C) and can cause frostbite and burns; it must be handled carefully with appropriate gloves and extreme caution. Under the EPA registration, the dry ice **must** be obtained from an EPA-registered manufacturing facility using a label purchased from a pesticide distributor, currently Univar. There are very few EPA-registered manufacturing facilities (currently just five in the northeastern United States), requiring long transport times. Although the dry ice may be transported in coolers with little loss of product, it cannot be transported inside a closed vehicle; it must be in the open bed of a pickup truck. Gas escaping from the transport coolers can build up in enclosed areas, such as inside a car or van, and increasing levels may cause fatigue and disorientation, and very high levels can lead to death. Coolers cannot be sealed—the gas buildup inside will cause the containers to explode. Because of these complications and risks, we do not recommend attempting to use rat ice until it is locally available. For more information, contact the PA IPM Program.

Other Devices and Repellents

Dryer sheets have not been shown to affect mouse behavior, and there is no reason they should. This is a total urban myth. Dryer sheets are chemically impregnated and can cause allergic reactions and exposure to phthalates and other chemicals. They should not be part of a pest control program.

Anecdotal evidence suggests repellents may be effective in enclosed spaces, such as farm tractor cabs. The product Fresh Cab was developed for use in tractor cabs during winter storage, when mice often infest and cause damage. However, these types of products are not going to be effective in open spaces with fresh air circulating. They also have very strong odors and could trigger asthma and other complaints.

While it is true that mice dislike the smell of peppermint, it will not cause them to leave a building; they will simply walk around the saturated cotton ball. Essential oils may also trigger asthma or other allergies and should not be used around children. Additionally, there is no evidence that mint-infused garbage bags deter rodents; observations in New York City have shown many rodent holes in "minty-fresh" garbage bags.

Mothballs are highly toxic to people, especially children, and should not be used in schools or childcares for any pest. Additionally, they are ineffective at deterring mice, and just like peppermint-soaked cotton balls, the mice will simply walk around them. Young children, however, often swallow mothballs, mistaking them for candy. Mothballs are a high-risk product that can cause kidney damage.

Special Considerations

Rats are very smart and very cautious. They learn rapidly and quickly become bait shy and trap adverse. If a rat lives longer than nine months, it may become difficult to kill. Professional assistance is required to eliminate rat problems, and sometimes creative techniques must be used. Some health departments may have vector control programs that may be able to assist.

Rat Mites

When rodents are eliminated, parasites living in their nests may emerge and briefly may bite humans. Rat mites (*Ornithonyssus bacoti*), which also parasitize mice, are tiny—the size of the period at the end of this sentence—and can move surprisingly quickly. Obtain samples by gently (crushed bugs are hard to identify) pressing clear cellophane tape down on top of the mite. While they will feed on people, leading to itching and complaints, they cannot complete their life cycle on people and will die in one to three days. They cannot transmit disease, and there is no public health threat. No spraying or other treatment is justified; the situation will resolve naturally. Make sure to remove all rodent nests and clean the area. Similar mites may infest bird nests (e.g., under eaves or on window-unit air conditioners) and enter schools and childcares after the baby birds have fledged and the family leaves the nest. Again, no pesticidal treatment is justified.

CENTERS FOR DISEASE CONTROL AND PREVENTION'S STANDARD OPERATING PROCEDURE FOR CLEANING RODENT FECES

Because of several outbreaks of Hanta virus, the CDC issued new guidelines on cleaning rodent waste and dead animals. Hanta virus is not carried or spread by house mice, but by white-footed mice, also called deer mice. These mice live in forests and meadows around our buildings, not in occupied human buildings. They may enter unoccupied seasonal buildings. Their feces carry the virus; when the feces dry out and disintegrate, the virus becomes airborne and can be inhaled. Illness is severe, with a 30 percent mortality rate. While rare, there have been cases of Hanta in Pennsylvania.

As discussed earlier, rodents can carry dozens of different pathogenic bacteria and viruses. It is important to protect pest control technicians and facility maintenance staff, as well as students, faculty, and staff, by following these cleaning guidelines:

Personal protection:

- Cross-ventilate room for at least 30 minutes before entering to clean.
- Do not stir up dust by sweeping, vacuuming, or dusting.
- Wear rubber or disposable nitrile or vinyl gloves.
- Make sure all cuts are covered.
- Respirators are recommended (cartridge style, full face, or goggles to protect eyes).
- Do **not** use dust masks; they may trap particles, increasing inhalation.

Handling feces and dead rodents:

- Spray rodent, feces, nests, and surrounding area with bleach water solution (1:10) until glistening.
- Let soak for five minutes.
- While wearing gloves, pick up the rodent, feces, nests, etc., with a paper towel.
- Place in plastic bag, seal, double bag, seal, and discard.
- Clean and sanitize the area.
- Remove gloves, wash and dry hands, sanitize.
- Use a waterless alcohol-based hand rub when soap is not available and hands are not visibly soiled.

IPM for Silverfish, Firebrats, and Booklice

INTRODUCTION

Silverfish, firebrats, and booklice are discussed together here because they occur in the same or similar habitats. They prefer dark, moist environments with a supply of starchy foods or molds. These nuisance pests can feed on wallpaper pastes, natural textiles, books, and manuscripts. They also feed on molds growing on various surfaces. Although they are all found in similar environments, silverfish and firebrats are not closely related to booklice.

Silverfish, firebrats, and booklice can live both indoors and outdoors. They are frequently introduced into a building with boxes of materials that have been stored in damp basements or attics, but they can also wander in from the outside. Silverfish and firebrats are fast moving and can travel throughout buildings. However, once these insects find a good source of food, they stay close to it. In general, they cause little damage, but they may cause people to take radical action based on their fear of insects.

IDENTIFICATION AND BIOLOGY

Silverfish and Firebrats

Silverfish and firebrats belong to an insect order called Thysanura. Insects in this order characteristically have three long, taillike appendages that are about as long as the body. These insects are wingless and have chewing mouthparts, long antennae, and a body covered with scales. The mouthparts of silverfish and firebrats are used for biting off small particles or scraping at surfaces. The most common species inhabiting buildings are in the genera *Lepisma* (silverfish) and *Thermobia* (firebrat). The silverfish *(Lepisma saccharina)* is about ½ inch long when fully grown and covered with silvery scales **(FIGURE 10.1)**. It is grayish to greenish in color and its body has a flattened-carrot shape. The firebrat *(Thermobia domestica)* has a mottled appearance with patches of white and black and is shaped similar to the silverfish **(FIGURE 10.2)**.

Silverfish and firebrats eat material high in protein, sugar, or starch, including cereals, moist wheat flour, starch in book bindings, sizing in paper, and paper under which there is glue or paste. These insects often attack wallpaper, eating irregular holes through the paper to get at the paste. Silverfish may bite very small holes in various fabrics, including cotton, linen (they can digest cellulose to some extent), and silk. Firebrats will feed extensively on rayon, whereas silverfish usually only damage it slightly.

Characteristics of the silverfish:

- Lays eggs in any season, usually in secluded places
- Has a three- to four-month life cycle from egg to adult
- Prefers moist areas (75 to 97 percent humidity) and moderate temperatures (70 to 80°F)
- Active at night or in dark places, and is rarely seen unless disturbed during cleaning
- May be found throughout the building—sometimes in boxes and books or in glass utensils and sinks they have fallen into
- Leaves yellowish stains on fabric

JOSEPH BERGER, BUGWOOD.ORG

FIGURE 10.1. Small blue silverfish.

CLEMSON UNIVERSITY–USDA COOPERATIVE EXTENSION SLIDE SERIES, BUGWOOD.ORG

FIGURE 10.2. Firebrat.

- Outdoors, lives in nests of insects, birds (especially pigeons), and mammals, and under the bark of trees

Characteristics of the firebrat:

- Lays eggs in cracks and crevices
- Has a two- to four-month life cycle from egg to adult
- Prefers moist areas with temperatures above 90°F
- Active at night or in dark places
- Found where heat and starches are present (e.g., in bakeries); also found in furnace rooms, steam pipe tunnels, and partition walls of water heater rooms

Booklice (Psocids)

The most common booklouse (*Liposcelis* spp.) is a small, grayish, soft-bodied insect with chewing mouthparts and long antennae. It is flat and superficially resembles the shape of the head louse. The common house-dwelling booklouse is wingless. The size of an adult is approximately 1/25 to 1/12 inch **(FIGURE 10.3)**. Because they feed chiefly on mold, booklice cause little direct damage to plants and wood. They are commonly found in confined areas like the bindings of books, where they eat the starch sizing along the edges of pages.

Characteristics of the booklouse:

- Has a life cycle from egg to adult that lasts about 110 days
- Prefers warm, moist conditions that are conducive to the growth of mold and mildew and require humidity of at least 60 percent
- Found in books and paper products
- Sometimes found on houseplants, where they may be feeding on honeydew (a protein-rich substance excreted by plant-eating insects such as aphids) or, more likely, the sooty mold that grows on the honeydew

KANSAS DEPARTMENT OF AGRICULTURE, BUGWOOD.ORG

FIGURE 10.3. Booklouse.

DETECTION

Silverfish are found in bookcases, on closet shelves, behind baseboards, and in wallpaper, window or door frames, wall voids, attics, and subfloor areas. They prefer bathrooms and kitchens because of the moisture. Firebrats will be found in similar but warmer areas. Both silverfish and firebrats molt as many as 50 times during their life, so the appearance of cast skins can be used to detect their presence. Booklice prefer damp and warm habitats, so they are most numerous during the spring and summer. New buildings are not immune to booklice infestation.

If you suspect that damage to books, carpets, curtains, or other materials is due to silverfish or firebrats, confirm your suspicions using the following test:

- Mix flour and water to the consistency of house paint.
- Coat one or more 3-by-5-inch index cards with the paste.
- Let the cards dry and place them where you have spotted the damage.
- If silverfish or firebrats are in the vicinity, they will be attracted to the card and will feed on the paste. Characteristic feeding marks appear as minute scrapings in irregular patterns. In addition, the edge of the card may be notched.

If you see groups of small, whitish insects in damp areas, suspect booklice, particularly if mold is present or the area smells moldy. Remember that booklice are considerably smaller than silverfish and lack the telltale three long bristles at their hind end.

Silverfish, firebrats, and booklice can also be detected by placing sticky cockroach traps in the area where damage is occurring. When the insects are caught, they should be preserved in alcohol for professional identification.

MANAGEMENT OPTIONS

Physical/Mechanical Controls

Dehumidifying

Booklice, silverfish, and firebrats are living indicators of excessive moisture. If the moisture is not eliminated, it may bring more serious problems,

such as termites, carpenter ants, and wood rot. Dehumidifying reduces the moisture content of the air. The following are some methods for dehumidifying an area:

- Mend leaking pipes.
- Ventilate closed rooms and attics.
- Eliminate standing water.
- Use a dehumidifier.
- Replace any single-glazed windows that repeatedly accumulate condensation with double-glazed windows.
- Use an anhydrous calcium carbonate or silica gel to absorb free moisture (do not use these agents in areas that are open to children).

Drying Stored Articles

Periodic airing and drying of articles stored in damp areas may help reduce the mold on which booklice feed. Disposing of moldy articles is often the simplest way of removing an infestation in an area.

Chemical Controls

If nonchemical methods alone do not solve the problem, then integrating a pesticide into your management program may be warranted. Pesticides must be used in accordance with their EPA-approved label directions. Some insecticides are registered for managing silverfish and firebrats and/or booklice indoors, whereas others are registered for outdoor use only. Pesticides must be used in accordance with their EPA-approved label directions, including that it is labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and Safety Data Sheets (SDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label.

Pennsylvania law allows pesticide applications in schools and childcares only by certified applicators, registered technicians, or noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must be posted in an area of common access for applications made at or in a school building at least 72 hours prior to and for 48 hours after the application. For applications made on school grounds the sign must be posted at the place to be treated at least 72 hours prior to and for 48 hours after the application. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied in a school building or on school grounds where students are expected to be present for normal academic instruction or extracurricular activities.

Diatomaceous earth, borate-based insecticidal dust products, and silica aerogel can be used to kill these insects. Diatomaceous earth and borate-based products must be kept dry to be most effective. Dusts should be applied only in cracks and crevices, crawl spaces, and other areas that are relatively inaccessible to humans and pets. Wear a dust mask or professional-quality respirator to provide proper lung protection when applying any dust.

Some baits for ants, crickets, and roaches are also labeled for silverfish and may be useful in some situations.

Residual sprays are labeled for silverfish and firebrats and can be applied where the pests are most commonly seen.

The U.S. EPA developed "Mold Remediation in Schools and Commercial Buildings Guide," a resource available at **www.epa.gov/mold/mold-remediation-schools-and-commercial-buildings-guide** that provides best management practices for the remediation and cleanup of mold to assist with eliminating mold on surfaces where booklice feed.

IPM for Spiders

INTRODUCTION

Despite their small size, spiders have evoked fear and revulsion in humans throughout history. Nursery rhymes and horror films malign them, but fears about spiders are largely unwarranted since most spiders are too small or have venom too weak to harm humans. In fact, they provide a great benefit by consuming vast numbers of insects in and around our homes and schools.

Spiders are arachnids, not insects. They have eight legs and two body regions, the cephalothorax (a head joined with a thorax) and abdomen. They lack wings and antennae. Almost all spiders have fangs and venom, but the bite of only a few are considered dangerous to humans. It is important to be able to differentiate between relatively harmless spiders and the those that are considered medically important and should be avoided and/or controlled.

There are only two spiders in Pennsylvania that are considered medically important: the black widow and the brown recluse. The spider that causes the most concern in the home or school environment in Pennsylvania is the black widow spider. Brown recluse spiders are **not** indigenous to Pennsylvania. Although a few have been found in Pennsylvania, they were probably transported in boxes or shipping materials from areas where they breed (the South and the Mississippi Valley). Both of these spiders are potentially dangerous to humans, and their bites may cause severe reactions or even death. However, these spiders will usually bite only if provoked, and then only under certain circumstances.

Other spiders that may produce painful bites or be of health importance include active hunters, such as some wolf spiders, jumping spiders, and sac spiders, and web builders, like some cobweb spiders and funnel weavers.

It is prudent to use caution when handling any larger spiders, even though most are harmless. Generally, spiders are not aggressive. Most bites occur when a spider accidentally becomes trapped against the skin or when a person picks the spider up.

Removing a Relatively Harmless Spider

Most spiders found in and around a school can be used as an educational opportunity to teach some interesting facts about these fascinating creatures and the food web. If any spider found in the classroom creates anxiety on the part of the teacher or children, and if the teacher wishes to remove it, it can easily be done by inverting a container over the spider, sliding a stiff piece of paper over the mouth of the container, and then releasing the spider outside.

IDENTIFICATION AND BIOLOGY

Black Widow Spiders

There are several species of widow spiders in the United States, but the black widow *(Latrodectus mactans)* is the only native species found in Pennsylvania **(FIGURE 11.1)**. The adult female black widow is normally a shiny, jet-black spider about ½ inch in body length. With legs extended, the female measures about 1½ inches long. The female has the well-known reddish hourglass marking on the underside of her abdomen. Because their webs are near the ground and the spiders hang upside down in the web, their distinctive marking is readily apparent. The adult male, which is not medically important, is small (about ⅙ inch long) and patterned with black and white body markings. Black widows like dry, undisturbed places, such as lumber and rock piles, stacked pots or baskets, rodent burrows, water meters, the underside of bricks and stones, and dry crawl spaces. Females stay in the web.

The female black widow spider spins an irregular, tangled web. The webs are typically constructed in quiet, undisturbed locations that

JEFF HOLLENBECK, BUGGUIDE.NET

FIGURE 11.1. Black widow spider.

are usually—but not always—close to the ground. The female spends her entire life in the web. If disturbed, she may drop to the ground to escape. Her eggs are placed in white, spherical sacs within the web. After hatching, the young spiders stay near the sac for a few hours to several days and then climb to a high point, wait for suitable air currents, and spin a silken thread so they can float on the breeze like a kite. This method of "ballooning" distributes them over a considerable distance. Once they land, the spiders begin to construct their own webs. A young black widow has the black legs and general appearance of an adult, but its abdomen is patterned with red, white, and yellow.

Brown Recluse Spiders

Brown recluse spiders (*Loxosceles* spp.) are extremely uncommon in Pennsylvania and probably found only in boxes brought up from the South. One species, *Loxosceles rufescens*, may be found in basements and utility tunnels. Brown recluse spiders *(L. reclusa)* are identified by their long, thin legs, an oval-shaped abdomen that is light tan to dark brown in color, and a very distinctive violin-shaped mark on their back **(FIGURE 11.2)**. This marking, with the violin "body" near the eyes and the "stem" of the violin extending backward, gives rise to their other common name, violin spiders. They have six eyes in three groups of two. Their overall size is ¾ to 1¼ inches long with the legs extended. The males are slightly smaller than the females.

As the common name "recluse" suggests, these spiders are shy, retreating from humans when possible. They prefer to build their webs in dark, undisturbed places on or near the ground. Unlike the black widow, brown recluse spiders hunt for prey some distance from their webs. They usually come into contact with humans because they have taken temporary refuge in clothing or bedding. Items left lying undisturbed on the floor, such as supplies, toys, or clothing, are perfect daytime refuges for these spiders. Such objects should be shaken out thoroughly if they have been on the floor for any length of time, particularly in regions where the brown recluse is prevalent.

JIM ECKERT, BUGGUIDE.NET

FIGURE 11.3. Wolf spider (*Tigrosa aspersa*).

Wolf Spider (Lycosidae)

These large spiders are sometimes found indoors in basements in late summer and fall when cooler temperatures arrive **(FIGURE 11.3)**. They do not construct webs but run rapidly after prey. They are not aggressive but may bite if handled. The bite is generally not dangerous. These and other spiders are best managed by cleaning and exclusion—keep screens in good repair, fix gaps around doors, and caulk cracks around window frames, pipes, and wires coming into the building.

Jumping Spider (*Phidippus audax*)

These spiders move in jumps or short rapid runs. They are hairy, stocky, and about ½ inch long **(FIGURE 11.4)**. This species is black with spots of

RICHARD VETTER

FIGURE 11.2. Brown recluse spider.

RYAN KALDARI, WIKIMEDIA COMMONS

FIGURE 11.4. Bold jumper (*Phidippus audax*).

STEVEN JACOBS, PENN STATE

FIGURE 11.5. Agrarian or yellow sac spider (*Cheiracanthium inclusum*).

orange or red on the top surface of the abdomen. At times, they are confused with black widow spiders, which are not at all hairy. Active during the day and usually outdoors, sometimes they are found inside on walls, windows, and screens. Generally, they do not appear in large numbers and can be removed individually.

Yellow Sac Spider (*Cheiracanthium* spp.)

These spiders have been associated with numerous cases of spider bites. The bite of a yellow sac spider causes a small, irritating spot that may not heal for 8 to 10 days. They are suspected of being responsible for most indoor bites. This yellow spider, which is about ¼ to ¾ inch long, may have a greenish tinge to the abdomen **(FIGURE 11.5)**. The jaws are brown and the legs are very smooth, with the front legs longer than the rear. The egg sac is a white, paperlike disk usually placed in a protected area, such as under a stone. They enter buildings principally in the early fall and are active for several months. They make small white webs in confined spaces where they spend the winter. In spring, they usually emerge from their white web cells and find their way outside. Outdoors, they do not build webs but instead construct a flat tubular sac opened at both ends inside rolled leaves or crevices or under loose bark or stones.

DETECTION AND MONITORING

Monitor for black widows at night with a flashlight or headlamp. This is the time when they move to the center of their webs and will be most visible. When making your inspections, focus on areas that are dark and undisturbed during the day but not necessarily close to the ground. Look in and around the following places:

- Small crevices anywhere from the foundation to the eaves of buildings
- Undersides of outdoor wooden furniture (e.g., beneath the seats in the corners where the legs are braced)
- Piles of wood, bricks, stones, or similar materials
- Openings of rodent burrows
- Water meters
- Cellar doors
- Outhouses
- Storage rooms

Black widow webs have high-tensile strength and, with a little experience, can be identified by the way they "pop" when broken. An experienced pest management professional can use this information to find webs during the day.

The brown recluse spider wanders at night searching for prey. It seeks dark, uninhabited areas for protection. Brown recluse spiders are usually found on floors and baseboards. Only rarely are they seen on desks and tables. Searches for this spider should concentrate on uninhabited areas close to the floor, particularly in boxes, around piles of paper, clothing, and debris, in closets, and under furniture. Periodic checks outdoors should focus on storage sheds, piles of debris or wood, and cracks in the soil or in foundations, walls, and window wells, especially if small children play near these areas. Employing sticky traps for monitoring is useful in establishing the extent of brown recluse infestations; sticky traps are also helpful in providing a measure of control.

BITES

Black widows are shy, retiring creatures that bite reluctantly, and then only in self-defense when threatened. However, when a female is defending her egg sac, she can become quite aggressive. A bite may not cause pain at first. However, after a few minutes, the bite site becomes quite painful. Symptoms from the bite of a black widow include headache, general body ache, nausea, chills, slight fever, shortness of breath, intense muscle pain, and rigidity of the abdomen and legs. Seek medical attention. If reactions are mild, treatment is usually not administered. However, medicine is available if symptoms do become severe. The bite of the black widow is usually more serious for children or aging adults.

Brown recluse spiders avoid areas of human activity. Bites are rare and usually the result of unused rooms suddenly being put to use or accidental contact resulting from pressing the spider

First Aid for Spider Bites

Wash the area around the bite, calm the victim, and consult a doctor as soon as possible. Those particularly at risk are the very young, aging adults, immunocompromised, or people with high blood pressure. Although the illness and lesions from bites of some of the spiders discussed here can be serious, deaths are rare. If possible, capture the spider so the specimen can be taken to a doctor. Proper treatment may depend on identifying the species. Even the squashed remains of the spider can be useful for identification purposes.

between the body and either clothing or sheets. The bites are almost always very unpleasant, producing an ulcerous wound called a necrotic lesion that turns dark within a day and takes a long time to heal. Young children, aging adults, and the infirm are most likely to be severely affected. Victims should seek medical attention.

Avoiding Spider Bites

If black widow or brown recluse spiders are found around your school, it is important to be cautious when working near these areas. Gardeners and custodians should be careful about where they put their hands when doing outdoor work, and wear gloves and a long-sleeve shirt when working around woodpiles and other items stored outdoors that are likely to harbor the spiders. Make sure students and staff can identify the medically important spiders and know their likely nesting and hiding places. Children should be taught not to tease spiders in their webs or poke at them, and not to put their hands in dark crevices without looking first. The dangers of spider bites should be explained without exaggeration to avoid unnecessary fears. Teach students and staff that the black spiders they see walking around are not likely to be black widows since the females do not travel away from their webs, and the males are not dangerous.

MANAGEMENT OPTIONS

Habitat Management

You can manage the number of spiders in an area by reducing their food supply. If flies are getting in, screens should be installed or repaired. At night security lighting may attract insects on which spiders feed, so outside lighting should not be placed directly over a doorway. Insects may also be attracted to poorly stored food or mishandled organic waste. Eliminating the food source for these insects will, in turn, reduce the food source for the spiders. Removing debris and excess clutter will also reduce the number of harborage sites available. Debris and stacks of wood, pallets, blocks, and similar materials should be moved a distance from schools and elevated off the ground as much as possible. Vegetation should be removed from the sides of buildings, and grass should be kept mown. For spiders already in residence, removing their webs and egg sacs discourages subsequent infestation. In most cases, vacuuming and reducing the spiders' food source will be sufficient to manage the problem. The two potentially medically important spiders—the black widow and the brown recluse—nest in undisturbed areas, often near the floor; therefore, thorough vacuuming in these areas from time to time can also help in their control.

Physical/Mechanical Controls

To achieve some kind of permanent control of black widow spiders, you must attempt to eliminate not only the spiders but also their preferred habitats. If this is not accomplished, another black widow may locate the same habitat and move in. If black widows regularly build their webs in certain locations indoors, try to modify these areas by increasing the light, caulking crevices, or reducing the insect population upon which the spiders are feeding. As previously mentioned, check window and door screens for holes that give insects access, and make sure that food and organic waste are stored properly to prevent insect infestations. To reduce or eliminate possible sites for webs outdoors, debris and litter should be removed and discarded. All crevices in foundations and walls that are of child height and wide enough to stick a finger into should be caulked or sealed.

Because many spiders prefer undisturbed places for nesting and hiding, periodic, thorough cleaning can help reduce their numbers. Floors should be kept well vacuumed. Boxes of paper and other items stored in closets or anywhere else that is dark and undisturbed should be handled carefully when first inspected. A small, handheld, battery-powered vacuum can also be used while checking through stored items. If a spider is vacuumed up, the vacuum bag can be placed into a plastic bag and then into a freezer. Most bites from spiders occur when a spider is disturbed or handled. Wearing leather gloves while searching through stored items can help prevent bites.

Chemical Controls

A wide variety of chemicals are available for the control of spiders. Misapplied chemical treatments may cause more harm than the real or perceived threat from spiders. Crack and crevice treatments may be necessary for the hunting spiders. Pesticides must be used in accordance with their EPA-approved label directions, including that it is labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and Safety Data Sheets (SDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label. **Pennsylvania law allows pesticide applications in schools and childcares only by certified applicators, registered technicians, or noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must be posted in an area of common access for applications made at or in a school building at least 72 hours prior to and for 48 hours after the application. For applications made on school grounds the sign must be posted at the place to be treated at least 72 hours prior to and for 48 hours after the application. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied in a school building or on school grounds where students are expected to be present for normal academic instruction or extracurricular activities.**

IPM for Ticks

INTRODUCTION

Ticks are not insects but instead are arachnids and relatives of spiders and mites. Four species of ticks are most commonly encountered in Pennsylvania: *Dermacentor variabilis* (American dog tick), *Ixodes scapularis* (blacklegged tick, also known as the deer tick), *Amblyomma americanum* (lone star tick), and *Ixodes cookei* (groundhog tick). For detailed images and size difference, see **www.tickencounter.org/tick_identification**.

Because public awareness of ticks and the pathogens associated with them have increased during the last 10 years, IPM strategies are critical to reduce and prevent exposure to ticks on school grounds. Children are a subpopulation at high risk for Lyme disease. The U.S. Centers for Disease Control and Prevention (CDC) data from 2009 to 2015 identified school-aged children (specifically boys) ages five to nine as the highest risk group for Lyme, emphasizing the need to reduce tick risk on school properties. Schools with wooded perimeters, bushy vegetation, and wetlands can harbor ticks and their animal hosts. Because children typically spend significant amounts of time on school grounds, they are at risk for tick exposure at schools with these and similar habitats.

The common ticks in Pennsylvania have four life stages: egg, larva, nymph, and adult (male and female). They are considered three-host ticks, meaning that each mobile stage (larva, nymph, adult) feeds on a different host animal. Ticks are ectoparasites (feed externally on vertebrate animals) that feed on a wide variety of mammals, birds, and, occasionally, domestic animals and humans. The life cycle of most ticks in Pennsylvania is about two years **(FIGURE 12.1)**.

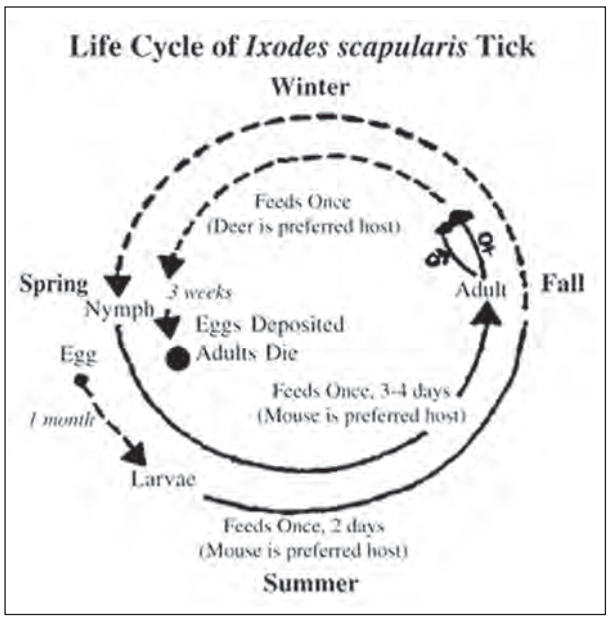

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FIGURE 12.1. The two-year life cycle of *Ixodes scapularis*, the blacklegged tick.

Eggs. Engorged female ticks, or those that were successful at taking a blood meal from a host, will lay up to 7,000 eggs within the leaf litter on the ground, generally in late the spring.

Larvae. In the first year, the eggs laid in the spring will hatch into six-legged larvae in late summer and early fall. These larvae will crawl up low vegetation, logs, or other nearby objects in search of a host. When they find a small mammal or other host, they attach themselves and feed for a few hours or up to three days, depending on the species. It is unlikely that these newly hatched larvae will carry tickborne pathogens like *Borrelia burgdorferi*, the causative agent of Lyme disease, because they become infected with pathogens from feeding from an infected host during their first blood meal, subsequently transmitting those pathogens to a new, uninfected host during their second and third blood meals. During feeding, the host will often be moving to different areas. Once the tick is engorged, it drops off the host, generally in a different location from where it first attached to the host, and molts to a nymph.

Nymphs. In the second year, nymphs will begin to emerge in the late spring and will be active throughout the summer. Peak activity is typically from May through July, but this depends on environmental factors and local weather. After molting, nymphs have eight legs and climb grass or plant stems and wait for a host to walk by, a behavior called "questing." Nymphs generally quest at 3 feet or lower, but because they are higher than ground level, they tend to attach to larger hosts than do larvae. Nymphs will feed off the new hosts for three to seven days before dropping off to molt. Ticks that were not infected with pathogens as larvae may become infected as nymphs during their second or third blood meals.

Adults. Nymphs will molt to adults in the fall. Like the nymph stage, adult ticks will climb nearby vegetation or other objects to quest for large hosts **(FIGURE 12.2)**. If adult ticks are unsuccessful at locating a host in the fall, they will quest during the following spring. Once blood-fed, adult females will

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FIGURE 12.2. A questing female blacklegged tick.

drop off the host, lay eggs, and die. Adults can be found in the fall through midsummer in some areas.

Host Use

When feeding, the tick uses its "teeth" (chelicerae) to cut the host's skin and then inserts its mouthparts. The feeding tube (hypostome) has many rows of barbs that anchor the tick to its host, making it difficult to withdraw by external force. Blood is pumped by a muscular pharynx and the salivary glands produce an anticoagulant that allows long periods of feeding without the host's blood coagulating. Pathogenic organisms are most often introduced into the host from the tick's saliva.

Ticks cannot fly or jump and are generally ambush parasites. This means that they typically wait for a host to come by before attaching to the host. Different species of ticks have preferences for different animal hosts, and this can also change based on the tick's life stage. Blacklegged ticks have shown affinities toward white-footed mouse and eastern chipmunk (the two primary reservoirs for the pathogen that causes Lyme disease, *Borrelia burgdorferi*), as well as white-tailed deer, raccoon, opossum, striped skunk, short-tailed shrew, and masked shrew. Rabbits also serve as a host for ticks. Birds can be hosts for ticks and may contribute to the spread of ticks as they fly. Some birds that are competent reservoirs for *Borrelia burgdorferi* include the American robin, house wren, Carolina wren, common grackle, and the veery thrush.

Deer do not infect ticks with the Lyme disease spirochete and are not affected by infected ticks. However, they are an important and common host that allows ticks to multiply. This results in more ticks within a given area available to pick up and transmit the pathogen from reservoir animals to future hosts. Excluding or reducing deer numbers may result in a reduction of ticks in an area, but some studies have shown an increase in questing ticks after deer reduction and exclusion. The role of different mammals in the tick and tickborne disease cycle in a variety of landscapes and land uses has yet to be determined.

IDENTIFICATION AND BIOLOGY

Ticks are important vectors of diseases causing illness in humans and animals. Three ticks are primarily responsible for pathogen transmission in Pennsylvania: *Ixodes scapularis* (blacklegged tick), *Dermacentor variabilis* (American dog tick), and *Amblyomma americanum* (lone star tick). Lyme disease is the most common vector-borne disease affecting humans in North America. Nationally, there has been approximately a 23 percent increase in reported Lyme-disease-confirmed and probable cases each year since 2013. A recent study put the number of Lyme cases at 300,000 annually, 10 times higher than previous reports. Other tickborne pathogens transmitted by ticks include human babesiosis, Rocky Mountain spotted fever, *Ehrlichia chaffeensis*, *E. ewingii*, *Rickettsia amblyommii*, Heartland virus, and southern tick associated rash illness (STARI).

Conventional habitat-targeted acaricide applications can be effective in reducing tick numbers, but they can have undesirable environmental impacts. In addition, the use of synthetic acaricides is generally viewed negatively by the public and may be highly restricted or not permitted on school grounds. There are limited alternative tools for tick management; however, integrated approaches have shown promise at reducing tick numbers.

American Dog Tick

This is the most commonly encountered tick in Pennsylvania **(FIGURE 12.3)**. The immature stages are often found on rodents, while the adults are frequently found on dogs. The American dog

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FIGURE 12.3. American dog tick adults and nymphs.

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FIGURE 12.4. Multiple life stages of blacklegged tick.

tick has distinctive white markings on its back and is about 5 millimeters long with short, stout mouthparts. When feeding, the adult becomes greatly engorged. The American dog tick is the major carrier of the pathogen that causes Rocky Mountain spotted fever. It can also transmit the pathogen that causes tularemia, and can cause tick paralysis. This tick does not transmit Lyme disease spirochetes.

Blacklegged Tick

Formerly called the deer tick, the blacklegged tick is established in every county in Pennsylvania. Larvae and nymphs feed on small animals and birds such as squirrels, mice, and grouse. Adults prefer deer and other large mammals. Any stage can feed on humans. The adult female is reddish and about 2–3 millimeters in length with long mouthparts **(FIGURE 12.4)**. This tick is well known as the vector of Lyme disease and has been known to carry the pathogens that cause anaplasmosis, babesiosis, Powassan virus, and borreliosis.

Lone Star Tick

This tick is found most often in the southern counties of Pennsylvania, but the range is currently expanding. The larvae feed on small animals, while the nymphs feed on many small and larger animals. Adults are usually found on larger animals. All stages are aggressive at seeking hosts and will feed on humans. This tick is light reddish brown, and adult females have a central white spot on the back. This tick is about 5 millimeters in length with long mouthparts **(FIGURE 12.5)**. The lone star tick is known to be a vector of tularemia, ehrlichiosis, tickborne typhus, and Rocky Mountain spotted fever, and causes tick paralysis.

MAT POUND, USDA AGRICULTURAL RESEARCH SERVICE, BUGWOOD.ORG

FIGURE 12.5. Lone star tick adults.

Groundhog Tick

The least commonly encountered of the four species listed here, the groundhog tick resembles the blacklegged tick and is about the same size. It is host specific for groundhogs but can be found on birds, small animals, and humans. It is not considered to be an important vector of diseases since it tends to feed mostly on groundhogs, although it has been found to be a vector of Powassan virus.

MONITORING

Ticks in Pennsylvania prefer moderate and humid deciduous forests. As with most arthropods, tick development is tied to temperature and development times will shorten with temperature increases. Cold temperatures arrest questing activity by most ticks, but host-seeking will resume when temperatures reach as little as 39°F. Harsh winters do not necessarily reduce tick populations or the risk of tickborne diseases. Therefore, monitoring for ticks should be considered during periods of warming above freezing.

Tick Dragging

Monitoring for ticks is routinely done with a tick drag. A "drag" is made from white fabric, typically medium-weight corduroy or flannel approximately 3 feet by 3 feet in size **(FIGURE 12.6)**. This cloth is stapled or sewn to a wooden dowel or PVC pipe and a 9-foot cord is attached to each end of the dowel. Weights (such as fishing sinkers) or a second dowel or board can be sewn in to the opposite end to keep the cloth on the ground as it is used.

As the user drags the cloth over the ground, leaf litter, vegetation, and questing ticks will grab onto the cloth. To standardize monitoring, the drag is inspected for ticks at fixed intervals (generally after 10–20 steps or 10–30 seconds). The user must be cautious to travel at a consistent, slow pace, and be careful when checking for ticks so they do not fall off. Generally, leaving the drag on the ground and slowly flipping the

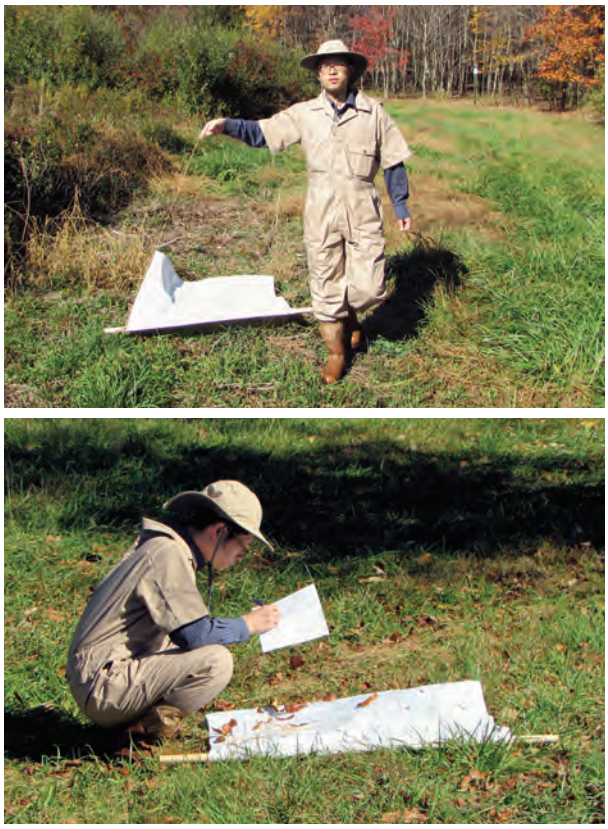

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FIGURE 12.6. Monitoring and collecting ticks through dragging.

material over will leave many of the collected ticks attached. Ticks can be counted and/or identified on the cloth or collected with sharp forceps into collection vials. Alternatively, ticks can be removed from drags with a lint roller. Tick drags will not work in wind, rain, or mist or when the vegetation is damp or wet. Visit Penn State Extension (**extention.psu.edu**) for more information on making and using tick drags.

Tick Flagging/Sweeping

Flagging or sweeping for ticks is like dragging, but a smaller cloth (approximately 24 inches by 24 inches), "the flag," is attached to one end of a pole (metal, wooden, or PVC) with the other end used as a handle **(FIGURE 12.7)**. The flag is brushed over higher vegetation, such as thick understory in wooded areas and brush and shrubs in open areas, or in edge habitats and along property borders where vegetation is thicker. Ticks are usually found within 18 inches off the ground.

As a rule, a drag or flag sampling will collect only one out of 10 ticks in an area. Repeated sampling at different times will increase the likelihood of finding a tick. Be sure to consider the personal protection suggestions in the section below if you plan to sample for ticks.

MANAGEMENT OPTIONS

The goal of an integrated tick management plan is to interrupt the tick life cycle and prevent or exclude ticks in the area from reaching students, faculty, and staff. This requires a combination of methods for greatest effectiveness in reducing the risk of tick bites and tickborne disease. Limited studies have evaluated the use of these available tools in integrated pest management for tick control. However, these tools have shown efficacy in different situations when used individually, so there is a high likelihood of effectiveness when used in conjunction with complementary methods.

Ticks require high humidity. Heavily shaded, damp (but not flooded) areas covered with leaf litter are ideal. Sites where host animal activity is concentrated are also important. Blacklegged ticks are often found in woodlots or wooded areas between lots, along edge habitats, and especially in unmaintained borders as well as along rock walls, woodpiles, and brush piles. Sites generally have a heavy understory of growth. All stages are rare on maintained lawns and rarely found in open, sunny areas. Generally, they will not be present on playgrounds or paved areas as long as these areas are set away from tick habitat.

Cultural, Design/Maintenance Controls

Personal Protection

- Wear light-colored clothing to make spotting ticks easier.
- In areas infested by ticks, wear long sleeves and long pants tucked into boots and/or socks. For added protection, brown packaging tape or

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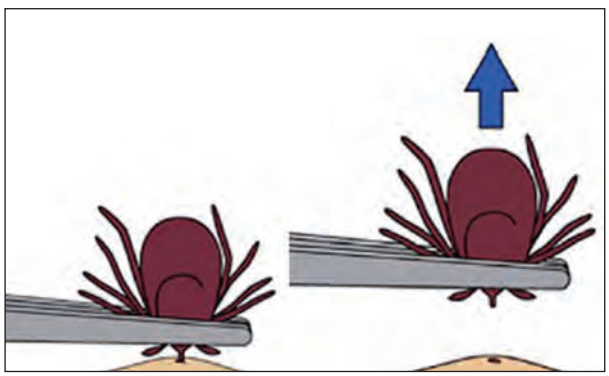
FIGURE 12.7. Flagging, like dragging, can be used to monitor for ticks. Flagging is best in areas of dense undergrowth or edge habitat.

similar material can be used to secure pants to socks.

- Walk in the center of paths and avoid brushing against vegetation.
- Repellents greatly enhance protection. Repellents containing 25 to 30 percent DEET or picaridin have been found to be effective and are recommended by the Centers for Disease Control and Prevention (CDC) (see **www.epa.gov/insect-repellents/find-repellent-right-you**). Guidelines for repellent use from the American Academy of Pediatrics should be followed for use on children (see **www.aappublications.org/content/34/6/16.2**).
- Examine yourself carefully for ticks after leaving the woods and known tick-infested areas. Check especially the hair, shoulders, armpits, waist, and inner thighs.
- If possible, take a shower. Showers following outdoor activities have been suggested to greatly reduce the risk of a tick bite.

Removing ticks after bite:

- To remove ticks, use forceps or tweezer to grasp the tick where it attaches to the skin and pull with a slow and steady motion until it is removed **(FIGURE 12.8)**. Do not twist the tick. Disinfect the area with rubbing alcohol. Do not apply mineral oil, petroleum jelly, heat, nail polish, or anything else to remove the tick, as this may cause it to inject a pathogen into the wound.
- Save the tick for future identification should you later develop disease symptoms. Preserve it by placing it in a clean container (such as a vial or Ziploc bag) and keep it in the freezer. Identification of the tick will help a physician diagnose the disease since many tickborne diseases are transmitted only by certain species.



CENTERS FOR DISEASE CONTROL AND PREVENTION

FIGURE 12.8. To remove a tick, grasp the tick as close to the skin as possible with fine-tipped forceps and pull back slowly with steady pressure.

Sanitation and Exclusion

- Manage the landscape to lower the humidity where ticks are likely to be found by replacing heavy wood or pine mulches or other groundcover with stone or gravel.
- Remove areas of leaf litter.
- Keep grass mowed to 3 inches or lower.
- Reduce cover for white-footed mice and other small mammals. Mice prefer wooded, brush-covered habitat. Prune lower branches of bushes to reduce habitat for mice, and clean up storage areas, woodpiles, and junk piles.
- Remove Japanese barberry and honeysuckle bushes. These plants have been linked to increased tick numbers.

Physical/Mechanical Controls

Landscape modifications

- Create at least a 3-foot buffer zone between vegetation and all grounds used for school activities (soccer, baseball, football fields, etc.) that can be filled with stone, gravel, or similar low-moisture materials. An additional 6-foot tick migration zone should be considered when placing playsets, buildings, and other objects on the property **(FIGURE 12.9)**.
- Use gravel pathways and mulches for landscaping. Keep these areas at least the width of a sidewalk (approximately 54 inches) to allow for human use without contact with bordering vegetation.
- Exclude deer by installing and maintaining a border fence that is at least 8 feet tall around the property.

CENTERS FOR DISEASE CONTROL AND PREVENTION

FIGURE 12.9. Buffer zones can be made between adjacent forested habitat and vegetation and athletic fields or other areas where children play.

Chemical Controls

Pesticides must be used in accordance with their EPA-approved label directions, including that it is labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and Safety Data Sheets (SDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label. **Pennsylvania law allows pesticide applications in schools and childcares only by certified applicators, registered technicians, or noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must also be posted on school grounds at the place to be treated at least 72 hours prior to and for 48 hours after the application. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied on school grounds and students are expected to be in the immediate vicinity for normal academic instruction or extracurricular activities.**

Synthetic Acaricide

A single springtime application of an acaricide (tick pesticide) can reduce the number of ticks around school properties. A second fall application may control adult ticks. Efficacy varies with the pesticide selected and circumstances of application. If you are considering applying an acaricide to your school property, identify regulations related to pesticide application on school grounds and follow state and local posting guidelines and the district's school IPM policy and plan.

Essential Oils

Essential oil products have been tested in the lab and field for effectiveness at repelling and/or killing ticks. Very few products have shown any effectiveness, and generally it is a repellent effect only. The challenge with essential oils is that residual activity of the product is limited after rain, and direct sunlight can degrade the active ingredients. In addition, many products are nonspecific and potentially hazardous to pollinators and other beneficial insects.

Entomopathogenic Fungi

Metarhizium anisopliae s.l and *Beauveria bassiana* are two naturally occurring soil fungi that are pathogenic to ticks. These fungi have been tested in the field and found to be effective at reducing tick numbers. In addition to being effective, recent studies have shown that there are minimal nontarget effects after application, and applications are safe for pollinators. A few commercially available formulations are currently available.

Control on Small Mammal Hosts

Currently, there are two commercially available options for control of ticks on small mammals such as white-footed mice.

- **Damminix Tick Tubes®.** These tubes contain permethrin-treated cotton balls that target larvae and nymphs primarily of blacklegged ticks on white-footed mice and other nesting small mammals. The mice collect the treated cotton and bring it to their nests, treating themselves and their offspring. Tick reduction after use has been variable in the field, but the use of this product may contribute to an integrated pest management program.
- **Select TCS™ bait boxes.** These bait boxes were developed to interrupt the host feeding cycle primarily of blacklegged ticks by treating small rodents, which are the primary hosts of the immature stages of this species. These bait boxes are nonlethal and contain a small amount of fipronil, a popular and effective pet tick collar and liquid ingredient **(FIGURE 12.10)**. Fipronil kills the tick but leaves the rodent unharmed. These bait boxes have been shown to be very effective, but proper placement is required and costs may be prohibitive for large properties.

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FIGURE 12.10. Select TCS™ bait boxes can be used to treat wild rodents for ticks.

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FIGURE 12.11. Four-poster feeders treat white-tailed deer for ticks.

Control on Large Mammal Hosts

Four-poster feeders. Permethrin is labeled for passive application to deer in many states via four-poster deer feeding stations **(FIGURE 12.11)**. These devices are provided with corn that attracts deer. Deer then feed from small amounts of corn released in the trough. While feeding, the deer are treated with permethrin labeled for passive application, which both kills and repels ticks, that is applied to the rollers ("posters") on each end of the device. The use of four-posters can be time consuming and expensive. However, in situations where deer cannot be controlled, this is a method of treating deer for ticks. Use of the four-poster device is suitable for all circumstances, but baiting is not permitted in Pennsylvania without appropriate permits from state wildlife authorities. If you have any questions or concerns about wildlife and its removal, contact the Pennsylvania Game Commission at 717-783-6527.

IPM for Wood-Damaging Pests

INTRODUCTION

The job of maintaining a building includes detecting structural pest problems before they become severe. Early detection means less costly repairs. Although the discovery of wood-destroying insects often generates panic and premature decisions, these pests are slow to cause new damage, so there is ample time to accurately identify the pest and decide on appropriate IPM protocols. Some of the work can be done by school personnel and the rest contracted out to a professional, or the entire job can be contracted out to professionals.

It is important to determine exactly which organisms are present and causing damage, as correct pest identification is critical to determining appropriate management strategies. The most commonly encountered groups are detailed, and the diagnostic keys (e.g., **TABLE 13.1**) included in this chapter will help distinguish between different wood-damaging organisms. Note that in some cases more than one kind of wood-damaging pest may be present. When wood-boring beetles are encountered, it is important to distinguish between those species that can reinfest wood and cause extensive damage, and those species that only infest fresh timber and whose damage is limited to one generation in structural wood.

If you are uncertain about which pest is present, take specimens to your county Penn State Extension office or a pest management specialist for a professional identification. The time and potential expense needed to correctly identify the pest will be compensated by the fact that you will be able to develop an effective management program for your school or childcare.

IDENTIFICATION AND BIOLOGY

Wood-Attacking Fungi

Fungi reproduce from spores present in the air and soil. Threadlike structures called hyphae grow from the spores and penetrate directly into wood. A mass of hyphae, called a mycelium, is frequently visible on the surface of the wood. A mycelium often takes the shape of a fan or a fluffy mat. Optimal growth occurs at temperatures between 50 and 95°F on wood containing at least 20 percent moisture.

The three major groups of wood-attacking fungi are **surface-staining fungi** (molds and mildews), **sap-staining fungi** (wood stains), and **decay fungi** (wood rots). Surface-staining and sap-staining fungi do not cause loss of structural strength

Table 13.1. Diagnostic Key to Wood-Attacking Organisms Based on Symptoms

SPECIFIC SYMPTOMS	PROBABLE CAUSE
FUNGI: Wood damaged and discolored with shrinkage and/or loss of structural strength; colored stains or dusty coating on underside of floors, walls, or ceilings	
Blue stain visible in sapwood	Blue stain fungus
Fan-shaped white fungal mat with large, 1-inch-wide, dirty white, brown, or black threadlike strands (mycelia)	Poria fungus, or "dry rot"
Soft, decayed wood with mycelia and checking (cracking) at right angles to the grain of the wood, particularly on floor or perimeter joists; wood looks brown and crumbles to a powder when touched	Brown rot
White mycelial mass covered with irregular specks or pocks	Fomes fungi
INSECTS: Holes, tunnels, galleries, or chambers on or beneath the surface of the wood	
Holes greater than ½ inch in diameter	Carpenter bees
Holes less than ½ inch in diameter	Wood-boring beetles
Galleries or chambers found in wood; wood surface is easily penetrated with a screwdriver or ice pick	Termites
Earthen tubes or tunnels running from soil to wood	Termites
Swarming winged insects at base of fence post, foundation, or indoors, or a collection of wings but no insect specimens	Ants or termites
Large bumble-bee-like insects flying around exterior near the eaves of the house; some enter large holes; damage mostly confined to siding or outer boards	Carpenter bees
Sawdust or tiny wood scraps on floor	Carpenter ants

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FIGURE 13.1. Brown rot caused by *Serpula lacrymans*.

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FIGURE 13.3. White rot on oak.

and will not be discussed here; however, they are evidence of moisture problems that need to be corrected. The third group, decay fungi, attacks the cellulose and lignin in wood and causes structural weakness. They are hard to detect in their early stages; however, advanced stages are quite evident from the changes in the wood's appearance.

Brown Rot (FIGURE 13.1)

- Characterized by white mycelial mats
- Causes wood to crack into small cubical pieces perpendicular to the wood grain
- Wood rapidly loses its strength and eventually crumbles to powder
- Wood changes color to a distinctive brown

Dry Rot or Water-Conducting Rot (FIGURE 13.2)

- A special kind of brown rot most often found in new construction
- Can disperse rapidly throughout wood, destroying large amounts in one to two years
- Characterized by large, papery, white-yellow mycelial fans
- Forms large tubes called rhizomorphs that are up to an inch in diameter and can conduct water up to 25 feet
- Rhizomorphs are dirty white to black and grow out and away from the moisture source
- Rhizomorphs allow the fungus to extend its growth into dry wood containing less than 20 percent moisture
- Wood surface may appear sound but wavy even though the interior is heavily decayed
- Relatively rare problem

White Rot (FIGURE 13.3)

- Makes wood look bleached
- Affected wood feels spongy when probed and is stringy when broken
- No abnormal shrinkage
- Wood strength gradually diminishes

Soft Rot (FIGURE 13.4)

- Seldom encountered in buildings, except where wood is in contact with constantly wet soil

J. SCHROT, HARUTA OVIDIU, UNIVERSITY OF ORADEA, BUGWOOD.ORG

FIGURE 13.2. Dry rot.

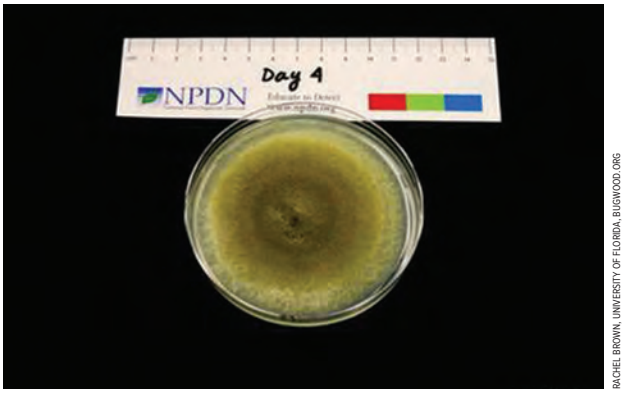

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FIGURE 13.4. Rhizopus soft rot.

- Develops in marine habitats in wood that is too wet for other decay fungi
- Attacks wood surfaces and produces a gradual softening inward

Termites

Termites are social insects that form colonies. The colonies can become quite large and, depending on the species, may contain up to one million or more individuals. Various aspects of colony labor are divided among castes, which are morphologically distinct: workers maintain and feed the colony, soldiers defend the colony, and the darkly pigmented, winged reproductive caste (kings and queens) reproduce and start new colonies. Reproductives "swarm," or fly away from their original colony, only at certain times of the year and often after certain environmental triggers.

Although a number of termite species occur in the United States, only two are native to Pennsylvania: eastern subterranean termites *(Reticulitermes flavipes)*, which are widespread and common, and dark southeastern subterranean termites *(Reticulitermes virginicus)*, which are less commonly encountered. The two species are difficult to distinguish and, besides differences in when mating swarms occur, have similar biologies, so they are considered together here.

West Indian drywood termites *(Cryptotermes brevis)* are found in Florida and along the Gulf Coast. They are occasionally introduced into Pennsylvania via infested furniture and other wood products but cannot survive outdoors and do not spread between structures. Drywood termites are unlikely to be encountered unless infested wood products from the southeastern United States are moved into and stored in school facilities.

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FIGURE 13.5. (L) Eastern subterranean termite (*Reticulitermes flavipes*); (R) drywood termite (*Cryptotermes brevis*).

Subterranean and drywood termites are easily distinguished based on the soldier caste **(FIGURE 13.5)**.

Subterranean Termites (*Reticulitermes flavipes* and *R. virginicus*)

Newly founded colonies grow slowly during the first six months as the queen only deposits 6 to 20 eggs. However, as the colony matures, the primary queen may lay 5,000 to 10,000 eggs per year. When a termite queen dies, the colony grows large, or satellite colonies develop due to a colony splitting or becoming separated, some workers may molt into secondary (or tertiary) reproductives. Secondary reproductives do not develop wings or mate, but they are capable of laying eggs. Although no single secondary reproductive can lay more eggs than the primary queen, several hundred may exist in an older colony and collectively lay the majority of the eggs. The presence of secondary reproductives can greatly accelerate colony growth.

Subterranean termites must be in regular contact with moisture and generally stay in contact with the soil. They construct distinctive earthen tubes to bridge the distance between soil and infested wood. The passageways protect them from predators and help prevent desiccation as they travel and are important visible clues to subterranean termite presence. In rare cases, subterranean termites live in damp wood above the soil, where moisture collects from a leaky air conditioner, regular condensation, or some other constant moisture source.

Initially, subterranean termites tunnel into soft spring wood, but as the infestation grows, they remove more and more wood until most of it is gone. They reinforce their excavations with "carton," a mixture of wood fragments and fecal material held together by saliva.

Reticulitermes flavipes and *R. virginicus* usually swarm on warm, sunny, windless afternoons, often after a brief rain. Most swarms occur in the spring, although smaller swarms can occur throughout the summer. These black, winged termites are the stage most commonly seen since the other castes do not expose themselves to light. Winged termites are attracted to light, and when they emerge within buildings, they swarm about doors and windows. After crawling or fluttering about for a short time, the termites break off their wings and locate a mate. Each pair attempts to locate moist wood in contact with the soil to start a new colony. Structural damage is not caused by the winged reproductives, although the presence of reproductives is indicative of a mature colony that may need to be controlled.

Drywood Termites (*Cryptotermes brevis*)

Drywood termites are subtropical insects that cannot survive cold, northern winters, so they are only encountered when infested material is imported from areas where the insects are found. While 18 species of drywood termites occur in the United States, West Indian drywood termites *(Cryptotermes brevis)*, which are present throughout Florida and coastal areas in the southeastern United States, are the species most likely to be encountered in Pennsylvania. Unlike dampwood termites, drywood termites can infest dry wood that is not in contact with the ground or other

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FIGURE 13.6. Drywood termite frass. Note the distinctive elongate hexagonal shape.

Table 13.2. Characteristics of Damage Caused by Common Wood-Boring Beetles

	WOOD ATTACKED		RECOGNIZING DAMAGE			
TYPE OF BORER	PART AND TYPE	CONDITION	EXIT HOLES	GALLERIES	FRASS	REINFEST?
Ambrosia Beetles (Curculionidae, Scolytinae)	Sapwood and heartwood of hardwoods and softwoods	Unseasoned, logs and lumber	Circular, 1/50–1/8 inch in diameter	Circular; same diameter as holes; across grain; walls stained	None present	No
Anobiid Powderpost Beetles (Anobiidae)	Sapwood of hardwoods and softwoods; rarely in heartwood	Newly seasoned or older wood	Circular, 1/16–1/8 inch in diameter	Circular, up to 1/8 inch in diameter; numerous; random	Fine powder with elongate pellets conspicuous; loosely packed in isolated clumps of different sizes; tends to stick together	Yes
Bark Beetles (Curculionidae, Scolytinae)	Inner bark and surface of sapwood only	Unseasoned, under bark only	Circular, 1/16–3/32 inch in diameter	Circular, up to 3/32 inch in diameter; random	Coarse to fine powder; bark colored; tightly packed in some tunnels	No
Bostrichid Powderpost Beetles (Bostrichidae)	Sapwood of hardwoods primarily; occasionally in softwoods	Seasoning and newly seasoned	Circular, 3/32–9/32 inch in diameter	Circular, 1/16–3/8 inch in diameter; numerous; random	Fine to coarse powder; tightly packed; tends to stick together	Rarely
Flat-Headed Borers (Buprestidae)	Sapwood and heartwood of softwoods and hardwoods	Seasoning	Oval, 1/16–1/2 inch in diameter	Flat oval, up to 3/8 inch in diameter; winding	Sawdustlike; may contain light and dark portions if under bark; tightly packed	No
Flat Oak Borer (*Smodicum cucujiforme*)	Sapwood and heartwood of hardwoods, primarily oak	Seasoning and newly seasoned	Slightly oval; 1/16–1 1/2 inch in diameter	Oval, up to 1/12 inch in diameter	Fine granules	No
Lyctine Powderpost Beetles (Bostrichidae, Lyctinae)	Sapwood of ring- and diffuse-porous hardwoods only	Newly seasoned with high starch content	Circular, 1/32–1/16 inch in diameter	Circular, 1/16 inch in diameter; numerous; random	Fine, flour-like, loose in tunnels	Yes
Old House Borer (*Hylotrupes bajulus*)	Sapwood of softwoods, primarily pine	Seasoning to seasoned	Oval, 1/4–3/8 inch in diameter	Oval, up to 3/8 inch in diameter; numerous in outer sapwood; makes ripple marks on walls	Very fine powder and tiny pellets; tightly packed in tunnels	Yes
Round-Headed Borers (general; Cerambycidae)	Sapwood of softwoods and hardwoods; some species in heartwood	Unseasoned, logs and lumber	Oval to circular, 1/8–3/8 inch in diameter	Oval, up to 1/2 inch in diameter; size varies with species	Coarse to fibrous; may be mostly absent	No
Wood-Boring Weevils (Curculionidae)	Sapwood and heartwood of hardwoods and softwoods	Slightly damp, decayed	Raggedly round or elongate, 1/16–1/12 inch in diameter	Circular, up to 1/16 inch in diameter	Very fine powder and very tiny pellets; tightly packed	Yes

sources of moisture. Drywood termites can infest wood products as small as a picture frame and leave a thin veneer of surface wood when excavating tunnels, so they can be extremely hard to detect. Signs a colony is present include swarming reproductives and small piles of characteristically shaped hexagonal frass or feces **(FIGURE 13.6)**.

Carpenter Ants

For information about carpenter ants, see the "IPM for Ants" chapter.

Wood-Boring Beetles

When dealing with wood-boring beetles, it is important to know whether or not a certain species can reinfest a piece of wood. Some species of beetles cannot reinfest wood and seeing their exit holes means they have done their damage and left. See **TABLE 13.2** for more information to help you identify some of the most important beetles.

Death-Watch Beetles, Furniture Beetles, and Anobiid Powderpost Beetles (Anobiidae)

Anobiid beetles are small (⅛–¼ inch long), reddish brown to black, and elongated with a very rounded back **(FIGURE 13.7)**. Wood moisture content of 13–30 percent is required for development, so anobiids are more frequently a problem in areas with higher temperatures and humidity. Furniture kept in centrally heated living spaces is usually too dry for them to infest.

Anobiids attack both hardwoods and softwoods and will feed on either newly seasoned or older wood. In Pennsylvania, they are the most common structure-infesting beetle. Although they feed mainly on the sapwood, they can also damage heartwood that is close to the sapwood. In the wild, they live in dead tree limbs or in bark-free scars on the trunks.

Female anobiids lay their eggs in small cracks or crevices on the surface of the wood. When the larvae hatch, they bore a short distance into the wood and then turn at a right angle and tunnel with the grain. Their tunnels get larger as the larvae grow. Eventually the tunnels become so numerous that they intersect, and the wood becomes a mass of fragments. Tunnels are packed with fecal pellets from the larvae. Larvae may take one to three years to complete their development, although rare cases of 40 years or more have been recorded.

Lyctine Powderpost Beetles

Bostrichid powderpost beetles generally attack seasoning or newly seasoned wood and rarely reinfest wood. One group of bostrichids, the Lyctinae (which was formerly considered distinct from bostrichids), routinely reinfest wood and are damaging pests.

Lyctines are small (⅛–¼ inch long), slender beetles that vary from reddish brown to black **(FIGURE 13.8)**. Lyctines attack only the sapwood (outer wood) of hardwoods.

PEST AND DISEASES IMAGE LIBRARY, BUGWOOD.ORG

FIGURE 13.7. Various anobiid powderpost beetles.

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FIGURE 13.8. Lyctine powderpost beetles, *Lyctus* (left) and *Trogoxylon* (right).

Female lyctines lay an average of 20–50 eggs in exposed areas of partially seasoned lumber with a high starch content. The hatched larvae bore down the vessels of the wood, making straight tunnels that then turn and become irregular. Most species complete their life cycle in 9–12 months, but they can develop more quickly if the temperature and starch content of the wood are favorable. The larvae pupate near the surface of the wood, and the emerging adults drill a hole through the wood to exit.

You are unlikely to see adult beetles during an inspection, and the larvae are always inside the wood. There is no outside evidence of infestation on wood that has been attacked for only a short time; however, once adult beetles emerge, you will see their small exit holes in the wood. You may also see piles of the fine, flourlike frass (beetle excrement) that sifts from the holes. Larvae usually pupate in the spring. The newly emerged adults bore holes straight out of the wood, and a large proportion of the females lay eggs in the same wood from which they emerged.

Old House Borer (*Hylotrupes bajulus*)

Old house borers are brownish black, slightly flattened, and about ⅝ to 1 inch long **(FIGURE 13.9)**. The segment just behind the head is marked by a shiny ridge and two shiny knobs that suggest a face with two eyes. Despite being called the "old" house borer, this insect is also very common in new construction. The beetle attacks coniferous wood, such as pine, spruce, hemlock, and fir. The female lays her eggs in cracks and crevices on the surface of wood, and the hatched larvae sometimes crawl around before finding a place through which they can bore into the wood. They remain near the surface, feeding on the sapwood and only gradually penetrating deeper as they grow. They do not feed on heartwood.

The larval period may be completed in two to three years, but it can take as long as 12 or 15 years in dry wood, such as that found in attics. Old house borer tunnels have a distinctive rippled appearance on the inside. Unless the moisture content is high, the tunneling proceeds slowly. The larvae, while chewing with their hard jaws, emit a rasping or clicking sound (very similar to the sound produced by clicking fingers). Although this beetle can reinfest wood, the likelihood of this happening in buildings that are occupied, heated, and well ventilated is small.

Carpenter Bees

Eastern carpenter bees (*Xylocopa virginica*) are solitary bees that superficially resemble bumble bees. Unlike bumble bees, which nest in the ground, carpenter bees excavate holes in wood and are often seen flying around porches and eaves. Carpenter bees have shiny black and nearly hairless abdomens, while bumble bees have abdomens that are covered in black and yellow or orange hairs **(FIGURE 13.10)**.

Carpenter bees do not eat wood but do excavate tunnels for shelter and as chambers in which to rear their young. They usually attack unpainted objects such as doors, windowsills, roof eaves, shingles, railings, telephone poles, and sometimes

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FIGURE 13.9. Old house borer adult and larvae.

(TOP) JUDY GALLAGHER, WIKIMEDIA; (BOTTOM) MARDON ERBLAND, BUGGUIDE.NET

FIGURE 13.10. (Top) Carpenter bee. (Bottom) Bumble bee.

wooden lawn furniture. A carpenter bee begins her nest by drilling a nearly perfectly round entrance hole (about ½ inch in diameter) into the wood. This hole is usually against the grain of the wood. When the tunnel is about 1 inch deep, the bee turns at right angles to the initial hole and tunnels with the grain of the wood. Bees prefer to attack wood that is greater than 2 inches thick.

While the tunneling and damage caused to wood by a single bee is slight, large congregations of bees and the activity across multiple years can cause significant damage. Additionally, bees commonly defecate below or near the tunnels, which can stain items and walls.

Male carpenter bees do not sting but are often noticed due to their confrontational flying. When an insect or person enters the territory defended by a male carpenter bee, the bee will often fly at or hover in front of the intruder, which can cause unnecessary panic. Males may occasionally bite, which may be painful due to their large size, but it is not cause for medical concern. Male carpenter bees can be distinguished from females by the presence of a white or orange face.

Female carpenter bees are capable of stinging but reluctant to do so; in fact, even if touched while feeding, they may ignore the touch or raise a leg or two and will only sting when extremely provoked (e.g., when grabbed or purposely forced against the skin). What evidence is available suggests that carpenter bee stings are less painful than honey bee stings, although caution should be used in case the person who is stung is allergic to honey bee stings.

Providing shelters (i.e., carpenter bee hotels) is an effective form of IPM. The pollination benefits far outweigh structural damage issues. If structures are painted, stained, or treated, carpenter bees do not choose that substrate for drilling and nesting. Providing structures that are easier to excavate (e.g., bee houses or hotels) will also help eliminate or reduce structural damage.

DETECTION AND MONITORING

Regular Monitoring

Monitoring means looking for signs of damage to the wooden parts of the structure on a regular basis. Information gathered from these regular site inspections should be recorded in a consistent manner so information can be compared between visits. Include a map of the site with notes about problem areas. Monitoring should show if a pest problem is getting worse and requires treatment, and if the treatment has been effective.

Monitoring for structural pests should be regarded as an ongoing responsibility, repeated every one to five years depending on the kind of problems in your area. Early detection of structural pest activity will result in considerably less expensive treatment later.

School Staff Responsibilities for Monitoring

All personnel responsible for maintaining wooden structures should be trained to identify the conditions that can lead to infestation by wood-damaging pests. (See the inspection checklist at the end of this chapter.) See the green box above for a list of equipment needed for monitoring. If monitoring by school personnel indicates signs of termite or wood-boring beetle activity, a more thorough inspection should be made by a pest management professional. These staff members should also be trained to recognize obvious signs of damage, such as those listed under symptoms in Table 13.1 at the beginning of this chapter. Although

Tools and Safety Equipment for Monitoring Termites and Other Wood-Boring Insects

- Flashlight with spare batteries and bulbs
- Screwdriver or ice pick for probing wood suspected of being infested
- Hammer or similar instrument for hitting wood and listening for indications of hollowness
- Ladder for inspecting roof trim and other off-ground areas
- Moisture meter with a range of at least 15 to 24 percent moisture
- Pencil, clipboard, graph paper, and measuring tape to make records precisely of the floor plan or elevation of the building where moisture is evident or wood is damaged
- Tools for opening access entrances into crawl spaces
- Hacksaw blade for checking earth-filled porches adjacent to crawl spaces; when inserted under the sill, the thin portion of the blade should not penetrate beyond the sill or headers
- High-quality caulk and a caulking gun to plug suspicious exterior cracks and crevices; silicone seal is also available in a thinner consistency that can be applied with a brush

major structural pest management decisions should be based on the recommendations of a trained inspector, having someone on the school district staff who is knowledgeable about structural pests and can supervise outside contractors may improve the quality of pest management and contain costs.

Using a Pest Management Service

When contracting for structural pest management services, the choice of a company should be based partially on their willingness to provide monitoring services for a fee separate and distinct from treatments. Some pest management professionals offer free termite inspections with the expectation that the inspection cost will be covered by the fees for the treatments that follow. You can use the checklist at the end of this chapter to confirm the thoroughness of an inspection performed by a professional. Inspect both the inside and the outside of the buildings.

If a professional is hired to do the inspection, ask to see locations that were infested and/or were found to have damaged wood. Discovering subterranean termite tubes or beetle damage is not necessarily evidence of an active infestation. Termite tubes or beetle exit holes or frass indicate only that termites or beetles were there at one time. In the case of beetles, the adults that made the exit holes may have been the last beetles that will ever emerge if they are from a species that does not reinfest wood. Treatment of inactive infestations would be an unnecessary expense. Ask for confirmation that living termites or beetles are present, as some companies do not make this confirmation normal practice.

The Pick Test

When monitoring your building, use an ice pick or screwdriver to probe wood you think might be decayed based on its color or other changes you detect. Insert the pick about ¼ inch into the wood and press sharply downward perpendicular to the grain. If the wood is sound, a long splinter will pull out of the wood along the grain (as shown in the top illustration below). If the wood is decayed, the splinter will be brittle and break into short pieces across the grain, especially at the point where the pick enters the wood and acts as a lever. You can also detect decayed wood by its lack of resistance relative to sound wood. Mud-sills (wood installed on footings) can be pick-tested without producing excessive visual or structural damage since they are not visible from outside the crawl space. Sometimes wood treated with a preservative on the surface is decayed inside. The pick test can help reveal these hidden pockets of decay.

Monitoring Wood

It isn't always possible to detect damaged wood by looking at the surface. Listening for sound differences while striking the wood surface with a hammer can help you find the hollow areas, and an ice pick or screwdriver can help you probe the wood for damaged areas. For many years, the only structural pest detection method available was visual observation by trained, experienced pest management professionals. This method has been improved by such inspection tools as the moisture meter.

Moisture Meters

A moisture meter with a 15 to 24 percent range will help determine whether or not the moisture content of the wood is high enough to support the growth of wood-inhabiting fungi, wood-boring beetles, or subterranean termites. The needles of the meter should be inserted along the grain of wood to give the most accurate readings. Temperature corrections should be applied to readings taken below 70°F and above 90°F (correction tables are supplied with meters). The meters should not be used in wood treated with waterborne wood preservatives or fire retardants.

Monitoring for Termites

There are several ways to identify termite activity. The observation of swarming reproductives is an indication of a current termite infestation in the area, but simply finding a pile of discarded wings can be misleading since winged termites are attracted to light and could come from other areas. If only swarming insects are seen, a distinction must be made between ants and termites. The easiest way to distinguish between the two is to look at their waists. A termite has a broad waist, while an ant has a narrow, wasplike waist that often has a distinct hump. Additionally, the four wings of the termite are all of equal length and nearly twice as long as its body, while the front and hind wings of an ant are unequal in length and not twice as long as its body length.

The discovery of a mud tube extending from the soil up to the wood is an indication of probable subterranean termite infestation (these tubes are described on page 123). If only one tube is located, monitoring for other tubes should begin immediately. Break open tubes to see if the termites are active or if the tubes are deserted; an active tube

will be rebuilt within a few days. Finding soil in cracks and crevices can also be an indication of subterranean termites.

Monitoring for Beetles

When wood-boring beetle larvae mature into adults inside the wood, they bore exit holes to the surface to emerge. Table 13.1 on page 121 can help you determine what kind of insect created the holes you find. If it is a beetle, the information in Table 13.2 on page 124 will help identify the kind of beetle and whether or not it is capable of reinfesting. Consulting with a professional is also advised.

Discovering beetle damage is not necessarily evidence of an active infestation. Signs that the infestation is still active include fresh frass that is the color of new-sawn wood and live larvae or adults in the wood. Where you suspect an infestation of the kind of beetles that do not emerge for several years (such as old house borers), you can confirm their presence by listening for the chewing sounds they make inside the wood. To amplify the sounds, use a doctor's stethoscope or a cardboard tube from a roll of paper towels. You can also place a cloth or piece of paper underneath the suspicious area for a week or two to monitor for the fresh debris and frass that are indications of activity for some beetles.

MANAGEMENT OPTIONS

Habitat Modification (All Wood-Damaging Pests)

No structural pest management program is complete unless the conditions that favor the survival of the pest are modified. Moisture in or on wood is the single most important predisposing condition for wood damage and structural failure.

Reduce the Moisture Level of the Wood

The investment in installing, fixing, or relocating gutters, siding, roofing, vents, drains, downspouts, and vapor barriers will pay for itself in long-term protection against wood-destroying organisms. Leaking pipes, drains, sinks, showers, or toilets should be repaired. For wood-boring beetles and fungi, often the only management measures necessary are fixing leaks, installing vapor barriers, and using central heating to dry out wood and keep it dry. The most common wood-boring beetles cannot establish themselves in wood with a moisture content below 8–10 percent. Wood must contain at least 20 percent moisture before it will support the growth of fungi. Few species of fungi can extend their growth into dry wood, and these fungi are relatively rare. In cases where wood is excessively damp or difficult to dry out, an immediate treatment by a professional may be necessary.

Ensure Proper Drainage under Buildings

If the soil under buildings is constantly wet or becomes wet after it rains, this problem should be corrected. Equip downspouts with plastic extensions to direct water away from foundations. Grade the soil around the building to slope gently away from the structure. Installation of a vapor barrier under the building will correct many situations, but more serious moisture accumulations need other measures. Coat foundation walls with rubberized asphalt membranes to reduce moisture under the building. Extreme cases may require the installation of a sump pump and/or Power Temp-Vent®. French drains can also be installed. French drains are lengths of perforated pipe covered with crushed stone placed around and below the foundation footings to catch and conduct water by gravity to a free-flowing outlet or sump pump. The drains are normally covered with a building paper or straw before being backfilled with soil to the normal surface grade.

Improve Irrigation or Landscape Practices to Decrease Water Collection Near Buildings

Water that falls on the sides of buildings from sprinklers can cause as many problems as natural rainfall.

Eliminate Direct Contact Between Wood and Soil

Ideally, wood should be at least 8 inches above the soil to prevent direct access by subterranean termites, keep wood from absorbing excessive moisture, and facilitate the inspection process. Wood in contact with the soil must be replaced with concrete. If wood is too close to the soil, remove some of the soil and grade it so that it slopes away from the building.

Replace Damaged Wood with Treated Wood

After managing the pest problem, if wood must be replaced, especially wood in vulnerable areas, it can be treated with borates (see the discussion under "Chemical Controls") to protect it from fungal decay and make it less attractive to termites. Whenever wood will be exposed to the weather, it is important to paint a water repellent on the bare wood before it is stained or painted. Depending on the product, water-sealed wood must dry for a few days to over a month before being painted. Studies show that wood treated in this manner resists weathering and decay many years longer than wood that is only painted or stained.

Replace Moisture-Prone Wood with Aluminum, Concrete, or Vinyl

Sometimes it is more cost-effective to eliminate wood altogether from the most vulnerable areas of the building.

Remove Tree Stumps and Wood Debris

Decaying stumps, construction debris, and wood scraps near or under the building can be a source of termite infestation. Remove all wood debris and stumps within 10 feet of foundations. Never bury wood pieces—they can become termite nesting areas. Small pieces of wood debris containing live termites can be soaked in soapy water to kill the insects. Wood debris containing live termites should be taken to a landfill or other area where the natural decomposing abilities of termites are useful.

Store Woodpiles Properly

Firewood or lumber piles should be constructed so that no wood rests directly on the ground. Use cinder blocks or concrete as a base on which to pile lumber or firewood and inspect the pile periodically. Large piles should be as far from the building as is practical; smaller amounts of wood can be moved closer to the building as they are needed, but do not store logs inside or in a place where they can touch the building or a wooden deck.

Plant Trees away from Buildings

Because trees and shrubs used in landscaping are often planted when young, a common mistake is to site them too close to a structure. Roots, branches, and eventually decaying stumps provide avenues for termite, carpenter ant, and wood-boring beetle infestations. Trees and large shrubs may also provide roof rats, squirrels, and other animals nesting places and access to the upper portions of the building. Leaves clog gutters, providing mosquito breeding sites and possibly leading to water damage.

Mulch

Using termite-resistant mulches may reduce the incidence of termite activity; however, opinions vary on their effectiveness.

Maintain Buildings in Good Repair

The most effective indirect strategy for managing structural pests is keeping buildings in good repair. Keep the skin of the structure sealed using paint, putty, and caulk. Repair cracked foundations by injecting cracks with patching compounds. Cracks should be chiseled out to ½ inch deep and ¾ inch wide before patching. Injectable bonding materials have some elasticity to resist cracking, whereas cement mixes are likely to crack if soil heaving or settlement causes ongoing foundation movement.

Inspect Lumber

Lumber and other wood items should be carefully examined for wood-boring beetle damage, such as small holes, sawdust, or fine wood fragments, before using or storing. Wooden furniture should be examined carefully for current infestations before being placed in the building.

Use Kiln-Dried or Air-Dried Lumber

Although close visual inspection of wood is essential, it is not a guarantee against beetle infestation. Some infestations can go undiscovered for years before damage is seen. Kiln-dried or air-dried lumber should be used in all construction projects.

Physical Controls

For termites, heavily damaged wood should be replaced with sound wood. Wherever possible, use lumber treated with wood preservatives such as borates (see "Chemical Controls" below). Dispose of infested wood as described above.

For wood-boring beetles, removing and replacing infested wood should be the first treatment option you consider. Carefully inspect wood in contact with the pieces that are removed to see if there is further infestation. In some situations, this may not be practical because the wood is inaccessible or labor costs are prohibitive. If any wood has been damaged to the point of structural weakness, it must be replaced or reinforced, no matter what treatment is used.

Chemical Controls

If nonchemical methods alone prove insufficient to solve the problem, then integrating a pesticide into your management program may be warranted. For information on pesticides and on how to select an appropriate pesticide for your situation, consult the Penn State Extension office in your county. Pesticides must be used in accordance with their EPA-approved label directions, including that it is labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and Safety Data Sheets (SDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label. **Pennsylvania law allows pesticide applications in schools and childcares only by certified applicators, registered technicians, or noncertified**

applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must be posted in an area of common access for applications made at or in a school building at least 72 hours prior to and for 48 hours after the application. For applications made on school grounds the sign must be posted at the place to be treated at least 72 hours prior to and for 48 hours after the application. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied in a school building or on school grounds where students are expected to be present for normal academic instruction or extracurricular activities. Always post durable signs where pesticides have been used in attics and crawl spaces so that future inspectors and repair technicians can identify and avoid the areas when possible.

Borate-Based Wood Treatments

Borates are fungicides and slow-acting insecticides that have extremely low mammalian toxicity. They are not repellent to insects (termites will construct tubes over borate-treated wood) but do act as antifeedants, which means that pests prefer not to feed on wood treated with borates. When insects feed on wood treated with borate or, in the case of wood-boring beetles that chew emergence holes through treated wood, the borate acts as a stomach poison to kill the insects over a number of days. Borates also act as fungicides by inhibiting the growth of wood-attacking fungi.

Borates are used in both the pretreatment of lumber for the construction industry and the remedial treatment of lumber in existing buildings. Use pretreated lumber to replace existing lumber and prevent reinfestation in areas of potential termite activity or areas that are vulnerable to rot. Crawl spaces and attics can be treated by a professional using a borate fogger, spraying or painting liquid solutions directly on the wood, or pressure-injecting the solution into the wood. A larger amount must be used in a fogger to get the same coverage as painting or spraying on the solution. Borates can be effective as an insecticide to eliminate small termite and wood-boring beetle infestations.

When applied properly, borate treatments are effective for 30 years or more. When lumber is pretreated or treated as a building is built, this can be very cost-effective. However, because some structural wood will be inaccessible after construction, the location of an infestation will determine if a borate treatment can be used and how effective the treatment can be.

Borates are water soluble, so they cannot be used to treat exterior wood unless the finish (paint or stain) or sealant is removed from the wood before treatment and then a finish or sealant is subsequently applied after treatment. Because borates can move easily through the soil and leach away from the area of application, they should not be used in close proximity to lakes, streams, ponds, or areas where there is standing water. High concentrations of borates are toxic to plants, so treatments of the perimeter of buildings can result in inadvertent poisoning of plants and shrubs near the building.

Desiccating Dusts: Diatomaceous Earth and Silica Gel

Both diatomaceous earth and silica gel are composed of silicon dioxide and kill by damaging the thin wax layer that covers the insect exoskeleton and helps them retain moisture; damage to this wax layer causes an insect to lose internal water, desiccate, and die. Diatomaceous earth is composed of larger particles that physically scrape the wax, while silica gel is composed of smaller particles that absorb the wax. While desiccating dusts are safe and effective when used alone, they are commonly combined with pyrethrins (a chemical insecticide).

Desiccating dusts are particularly useful and effective against wood-boring beetles in confined spaces, such as attics and wall voids, where they can remain effective for the life of the building. Diatomaceous earth has been used against termites as a repellent, but the use of silica gel for termite control is more common. It is important to note that the product described here is not the "glassified" diatomaceous earth used for swimming pool filters, but rather "amorphous" diatomaceous earth.

Insecticidal Dust for Carpenter Bees

Insecticidal dust should be applied directly into nest openings. This is best accomplished by using a duster that will puff the dust up into the tunnel and coat the sides. After the insecticidal dust is applied, the holes should not be plugged. Rather, the bees should be able to pass freely through the nest entrance where they will contact the dust and distribute it inside the tunnels. Additionally, newly matured bees will emerge through the openings and contact the dust placed there. It is a good idea to treat in the spring, when bees are first observed, again in midsummer to kill any bees that may not have acquired a sufficient treatment when they emerged, and a third time in early fall to contact any overwintering bees occupying the tunnels. In the fall, the holes should be filled with wood putty

or wooden dowels and the entire wood surface painted or varnished. Stained wood is not usually protected from attack.

Termite Baits (Subterranean Termites)

The termite baiting strategy involves two steps: finding termites by placing baits in appropriate sites and then exposing them to a slow-acting toxicant. The toxicant must be slow acting so that termites have time to go back to the nest to spread the toxicant among their nest mates through food sharing and mutual grooming. Since termites habitually wall off members of the community and/or galleries when they sense a problem with their food supply, the toxicant must work slowly enough that it goes undetected until a good portion of the colony has been exposed.

Baiting may eliminate a termite colony over a number of months (conventional chemical barrier treatments only try to prevent termites from entering a structure), but elimination may not be practical or necessary. Baiting is an ongoing process—you may eliminate one colony or portion of it, but another colony may eventually attack the structure in the future. Adequate control can probably be achieved by reducing the colony enough that no termites are seen in structures and no professional pest management callbacks are necessary.

Safety of baits. Much smaller amounts of active ingredient are used in baits than are used in chemical barrier treatments, so there is less risk. Most of the active ingredients used in termite baits have low acute toxicity, and the concentrations in which they are used are generally low. Manufacturers are designing bait stations to be self-contained and tamper resistant to protect children and animals from accidental exposure.

When to bait. Because termite activity is seasonal, baiting is more effective at certain times of the year. The best time to bait the eastern subterranean termite *(R. flavipes)* is in the late spring and early summer. Less activity is expected from November to February, although active termites have been found in bait stations in December and January.

Two types of baiting strategies. There are two general types of food baiting that can be used: perimeter baiting or interceptive baiting. If the whereabouts of the termites are unknown, perimeter baiting is used. Wooden stakes, bait blocks, or plastic monitoring stations are set around the perimeter of a structure either in a continuous circle or in a grid pattern. Perimeter baiting relies on the certainty that termites foraging at random will eventually discover the bait. Once termites have been located, by either perimeter baiting or finding shelter tubes or active galleries, interceptive baiting can be used. Here, actively foraging termites are intercepted with a bait. Interceptive baiting of structures has a disadvantage in that quite often termite damage already has been done, and even though the colony is eliminated, the wood may have to be replaced.

Termite Barriers

Using insecticides as termite barriers in the soil relies on uniform distribution in the soil. In some cases, soil characteristics or structural defects may prevent this, and barriers will fail. A pest management professional can provide conventional termite treatments. (For more information on this extensive process, refer to Mallis [1997], pp. 285–98.)

INSPECTION CHECKLIST FOR DETECTING STRUCTURAL DECAY AND PEST DAMAGE

Check the following locations for structural decay and pest damage. Check both visually and by probing with a pointed tool, such as an ice pick (see page 128). Look for signs of moisture, damaged wood, insect frass, and termite earthen tunnels and/or fecal pellets. For inspection tips and structural and repair guidelines, see also *Pest Prevention by Design* (2012) at **sfenvironment.org/download/pest-prevention-by-design-guidelines**.

Roof, Overhangs, Gutters, Eaves, Trim, and Attic

Check the roof for cracks, missing shingles, and other openings where moisture might enter. Shingles should extend ¾ inch or more beyond the edge of the roof and form a continuous dripline at the eave and end rafters or at the rake boards that cover the end rafters.

Remove leaves from the roof surface and replace any missing shingles. Install flashing or an aluminum drip edge under the first course of shingles to divert rainwater from the fascia board and walls of the building. Be careful not to block eave vents. Install flashing; it should curl over the forward edge of the fascia board about 2 inches and then run about 6 inches beyond a vertical line drawn from the inside face of the wall studs. Check for the formation of masses of ice on the roof near the gutters, which can lead to water filtration and/or excessive condensation on interior attic walls.

Gutters

Check for poorly sloped, clogged, rotted, or leaking gutters that can lead to eave, overhang, or siding leaks and rots. Remove leaves and twigs that absorb moisture and cause rot. Flush gutters with

a hose before the rainy season. Install downspout leaf strainers and gutter guards.

Attics

Extra effort is needed to inspect areas that are difficult to see or reach. Use a good light source and a probe. Search for rain seepage or decay around vent pipes, antennas, wall-top plates, skylights, and other vents.

Eaves, Overhangs, and Fascia Boards

Make sure there is at least 18 inches of overhang to allow for proper water runoff. Extend short overhangs. Search for soft, tunneled, cracked, or exposed areas. Check areas where algae, moss, lichens, or discoloration occurs—these symptoms may indicate moisture problems and termites.

Flashings

Make sure areas around vents, chimneys, and dormers are flush and well sealed. Rusty or broken nails can cause problems in flashings. Aluminum or galvanized nails are required to prevent electrolysis (a chemical reaction between dissimilar metals that causes the nails to disintegrate). Seal nail head and flashing joints with marine-quality caulk or silicone (tar preparations are cheapest, but they crack after a few years in the sun).

Damaged or Discolored Areas

Search for exposed areas that are soft, tunneled, cracked, rotted, or blistered. Check for algae, moss, lichens, or discoloration since these areas indicate potential openings for fungi and/or insects. Locate the sources of moisture and make the necessary repairs.

Outside Walls

Rusty Nails

Check for rusty nails or nail staining, which indicates moisture within the wall and/or the use of nongalvanized nails. Replace rusty nails with aluminum or galvanized nails or screws.

Deteriorating Paint

Look for signs of deteriorating paint, such as loss of paint sheen and bubbling and peeling. Scrape and sand affected surfaces and repaint. If the wood seems soft, weak, or spongy, scrape out the spongy parts. If holes are smaller than ½ inch in diameter, fill them with caulk. Larger holes can be filled with epoxy wood filler. If holes are very large, replace the wood.

Stained or Buckled Siding

Stained or buckled siding (with or without peeling paint) is a symptom of underlying moisture, rot, or insects. Check for moisture caused by splashing rain or lawn sprinklers. If possible, remove the source of the moisture and refinish or replace the damaged wood. Consider using a more durable material, such as aluminum siding. Pressure-treated woods are treated with toxic materials, and their use should be minimized.

Damaged Wood Junctions

Moisture and insect problems often occur where wood pieces join or abut, particularly when there is shrinkage, splintering, or settling. Corners, edges of walls, roof/siding intersections, and siding/chimney contacts are particularly vulnerable. Apply water repellent and caulk to these joints and monitor them regularly for building movement.

Weathering of Exposed Lumber/Beam Ends

Check for expanded, split, or cracked lumber ends, which provide access for moisture and insects. Even previously treated wood is subject to attack if the openings are deep enough. Caulk cracks and monitor for further developments.

Cracked or Loose Stucco

Search for cracks in stucco, especially stress cracks around windows and doors. These conditions can provide access to moisture, termites, and decay organisms. Caulk cracks. If they are large, consider replacing the old stucco.

Moisture Accumulation around Laundry Facilities, Especially Dryer Vents

Check for signs of moisture accumulation around the vent. Modify the vent to direct exhaust air away from the building.

Moisture Associated with Pipes and Ducts

Check for moisture where ducts pass through wooden parts of a building. Also check downspouts during heavy rains for leakage and proper drainage. Insulate ducts, install splash guards below downspouts, repair the spouts, and direct water away from buildings.

Moist Window Sills, Windows, or Doors

Check for cracked sills and casings and poorly fitted windows and doors. Badly fitted doors may indicate warping of the door or its casing from excessive moisture or uneven settling. Moisture problems can alter door jambs. Warped and cracked sills and poorly fitted windows and doors allow water access, which aids decay and provides initial insect habitat. Caulk cracks and monitor for further development. Warped door thresholds and

jambs may need to be replaced, and casings may need to be repaired if the cracks are too large to caulk effectively.

Foundation and Grade

Soil Surface

Make sure the soil surface slopes away from the school building in order to carry water away from the foundation. Seepage under the foundation will cause it to crack and settle. Add fill to direct the water away from the building, but make sure there is at least 8 inches between the top of the fill and the sill. If clearance is small, consider installing foundation "gutters." Install splash blocks and perforated pipe. Check their performance during rains or test the system with a hose. A sump pump also can be used to move water away from the foundation.

Low Foundation Walls and Footings Allowing Wood-to-Soil/Mulch Contact

Check for wood in contact with the soil. Wood should be at least 8 inches, preferably more, above the soil surface. Low foundation walls or footings often permit wooden structural members to come

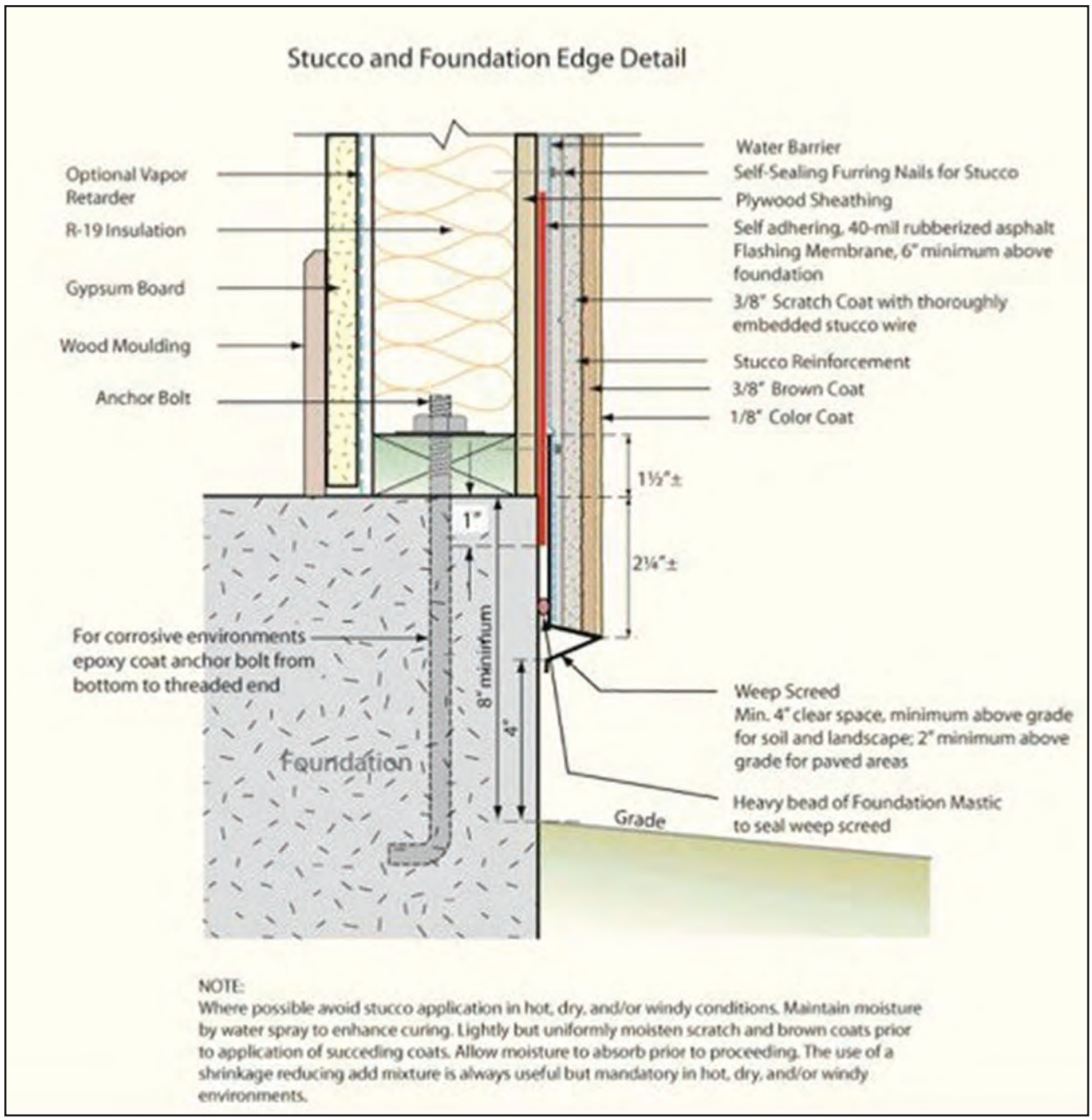

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FIGURE 13.11. Sealing for stucco walls with offset framing and standard weep screed.

in contact with the soil, providing access for subterranean termites. Repair these areas or install subgrade concrete "gutters" where the building sills sit too close to ground level. Remove wood that comes in contact with the soil and replace it with concrete. Remove mulch that comes in contact with the building foundation and replace it with gravel such as pea stones.

Foundation Cracks

Check for cracks that give decay organisms access to wood. Cracking may also indicate uneven settling. Monitor cracked walls for discoloration and seepage during rains. Termites use cracks to gain access to wood hidden from view. If the problem is serious, the foundation may need repair.

Brick Veneer or Stucco Applied to the Foundation

Check the bond between the veneer or stucco and the foundation wall. If it is failing, moisture and termites may have a hidden entrance to wooden portions of the building. Remove the loose covering and explore the extent of decay. "Synthetic stucco," also known as exterior insulation and finish systems (EIFS), is a popular construction material that is applied over foam board **(FIGURE 13.11)**. The bottom edge of this board must be properly sealed because insects can easily tunnel through it and gain access to wall cavities.

Crawl Space, Basement, and Foundation

Make sure enclosed crawl spaces are vented to allow moist air to escape. Milder climates are especially vulnerable to dry-rot fungus. In humid climates, the subfloor can be wet from condensation from interior air-conditioning. Shrubbery or other obstacles that block airflow through foundation vents cause air underneath the building to stay warm and moist—an ideal environment for termites.

Clean existing vents of dust, plants, and debris. Foundation vent openings should equal 2 square feet of opening for every 25 linear feet of outside wall. An opening should occur within 5 feet of each corner. Add more vents if needed. The top edge of the concrete under all vents should be at least 6 inches above the finished grade to allow sufficient ventilation. Vents located below grade may require wells to prevent surface water from entering subfloor and basement areas. Divert roof drainage away from vents.

Corners of the Building

Check for moisture accumulation and stains at junctions of wood surfaces in these areas. Install additional cellar or crawl space vents.

Enclosed Areas

Check for proper ventilation under staircases, porches, and other enclosed areas since these are vulnerable to moisture accumulation. Look for decayed, discolored, or stained areas. Adjust or add venting.

Vapor Barriers

Check for condensation on the subfloor and/or sill, which may indicate the need for vapor barriers on the subfloor and on the soil surface in the crawl space. Such barriers can be installed to reduce the moisture resulting from poor soil grading, unexpected seepage, or high rainfall. Cover the crawl space soil surface with a 6-mil polyethylene vapor barrier. Use polyethylene instead of roofing paper, which can rot. A slurry of concrete can be placed over the plastic to protect it from rodents. Where condensation continues, consider installing extra vents or electric-powered vents whose fans and openings are operated automatically (Powered Temp Vents®). A sump pump can be installed to remove standing water.

Wood-to-Stone or Wood-to-Concrete Contacts

Check to see whether the wood is pressure treated (look for perforation marks from the chemical injection on the surface of the wood). Replace untreated wood with rot-resistant or pressure-treated wood. Be sure sealing material is used between the wood and stone or concrete and place a metal washer between posts and footings.

Leaky Pipes or Faucets

Even small leaks keep the wood or soil underneath continuously moist, thereby setting up ideal conditions for termites. Areas where rain splashes on walls should be protected with rain guards. Do not allow sprinklers to spray the side of the building. Fix all leaks and change irrigation practices where necessary.

Water- or Space-Heating Units

Check to see whether the heating unit is insulated. If the soil near the flame is kept warm throughout the year due to lack of insulation, microbial and insect development will be accelerated. Insulate the heater and cover the soil with concrete.

Paper Collars around Pipes

Since paper is almost pure cellulose, it is extremely attractive to termites and should be removed and replaced with other insulating materials that termites cannot eat.

Miscellaneous Openings

Meter boxes, bathroom inspection doors, pet doors or openings, milk delivery doors, and air exhaust vents should be checked for water access, cracks, termite pellets, and soft areas.

External Areas

Porches

Check for wooden steps touching the soil and inspect for possible decay or termite access. The porch surface must slope away from the building to carry rain away quickly. If the porch does not slope away from the building, check siding for moisture and termites. Tongue-and-groove flooring is a water trap. If there is a space between the porch and the building, check for drainage problems. Caulk and repair cracks. Fill spaces between tongue-and-groove floorboards with caulk or resurface and refinish with wood-sealing compounds and appropriate paint. Another floor can be placed over the first.

Earth-Filled Porches

Soil should be at least 8 inches (optimally 12 to 18 inches) below the level of any wooden members. Remove the excess soil where possible, regrade to enhance drainage, and redesign the porch to eliminate earth/wood contact.

Planter Boxes

Check planter boxes that are built against the building. Move them 6 inches away from the building. When they are in direct contact with the building, they allow direct termite access to unprotected veneer, siding, or cracked stucco. One remedy is to provide a 6-inch space between the planter and the building to allow for air circulation and visual inspection. This air space must be kept free of debris.

Trellises and Fences

Check for wooden portions of the trellis that touch the soil and are connected to the building since they provide a direct link to the building for wood rot and termites. Check fence stringers and posts for decay. Cut off the decay and install a concrete footing for trellises and fence posts. Replace decayed stringers and leave a small gap between the stringers to allow air circulation. Separate wood and concrete with metal washers.

Wooden Forms around Drains

These are sometimes left in place after the concrete foundation is poured, providing termites with access routes to inner walls. Areas and joints around pipes rising from slabs should be sealed with tar or other adhesive to prevent water and termite access. Caulk the holes and monitor them for decay and excess moisture.

Gate Posts, Fence Tie-Ins, Abutments, and Columns

Inspect these for weakness and rot, especially around areas adjacent to the soil. Exposed areas can provide cracks for termite invasion. If wooden posts go through concrete into the soil below, check the posts for evidence of termite attack. The bottoms of these posts should be cut and replaced with a concrete footing. Cut post tops at an angle to promote runoff and prevent water from penetrating the vulnerable end grain.

Balconies and Landings

Surfaces should be sloped away from the building. Check the junction of floor and siding for moisture and insects.

Wood Debris under and around Buildings

Pieces of wood, particularly partially buried tree roots or construction lumber, can help support a termite colony until the population grows large enough to attack the building itself. Since cardboard boxes are very attractive to termites, they should be removed from crawl spaces or basements with earthen floors.

Interior Locations

Areas with water stains or mold growth indicate excessive moisture and should be analyzed for corrective action. Pay special attention to areas listed below.

Kitchen Pipes

Look for condensation and leaks, especially where pipes enter walls. Repair leaks and insulate pipes where condensation is excessive.

Counter Areas

Check around and below sink surfaces for moisture and decay. Caulk or otherwise protect wall surfaces from moisture. Subsurface areas damaged by water leaking from above may be tolerated if the surface leaks are repaired.

Exhaust Vents

Check for moisture leaks from outside. Repair with caulk or water-resistant sealing material or replace the vent and the rotted wood around it. Use extra flashing to fill the gap.

Toilets

Check the integrity of the floor around each toilet base by thumping it lightly with a hammer.

Check the wax seal for leakage at the floor/toilet pedestal intersection. If you detect leakage, check the cellar or crawl space beneath the toilets to see whether it has caused damage. Replace the wax seal if necessary and repair the surrounding water damage.

Showers and Sinks

Check all sinks and showers for a sound caulk seal. Look for splash-over on the floors from inadequate water barriers or user carelessness. If moisture is visible from crawl spaces, it may indicate a crack in the floor or drainage pipes. If moisture is visible in the ceiling, it may indicate cracks in the delivery pipes. Repair or replace flooring materials, pipes, drains, or sink basins if necessary. Sealing compounds may be useful when leaks are relatively recent and small, especially if termites have not been found; however, regular monitoring is necessary if sealing materials are used.

Tile Walls

Check for mildew stains. Make sure the grout in tile walls has a silicone coating to prevent water penetration. Clean the walls regularly to remove mildew and improve ventilation.

Ceilings

Check for blistered areas since these can indicate moisture leaks in the area above or inadequate installation of a vapor barrier. Repair leaks and faulty vapor barriers.

Windows

Check for moisture accumulation and/or water stains on window frames and walls. Search for evidence of decay or insect attack next to glass areas where condensation accumulates, at edges where moldings meet walls and casings, and in window channels and door jambs. Gaps between window and door casings may be avenues for hidden moisture and insect access. Check interior walls beneath windows, especially if they are regularly wetted by garden sprinklers. Open windows when feasible to improve air circulation. Install double- or triple-glazed windows when replacement is necessary. Use aluminum frames if wooden frames are decaying. Adjust or move sprinklers so water does not hit windows.

Closets

Check coat and storage closets for dampness. A light bulb left burning continuously in a damp closet will often generate enough heat to dry it out, but make sure the bulb is far enough away from stored materials to avoid creating a fire hazard. Containers of highly absorbent silica gel, activated alumina, or calcium chloride also remove moisture from the air in enclosed spaces. These agents should be placed out of the reach of children to avoid accidental exposure. Avoid use of silica gel where children may tamper with the containers. These chemicals can be reused after drying them in the oven. Small exhaust fans can also improve closet ventilation.

Floors

Sagging or buckling floors can indicate shrinkage or rot from excessive condensation or water leaks. Gaps between the floor and baseboards can indicate wood damage from insects, fungi, or water-triggered swelling and shrinkage.

IPM for Yellowjackets, Hornets, and Paper Wasps

INTRODUCTION

Yellowjackets, hornets, and paper wasps are commonly encountered social wasps that can be beneficial or problematic depending on the situation in which they are encountered. They are important predators and scavengers that help manage pests (especially caterpillars) and recycle organic materials, but they can sting humans and pets.

"Yellowjacket" and "hornet" are the common names given to wasps in the genera *Dolichovespula*, *Vespula*, and *Vespa*; unless otherwise noted, and for the sake of simplicity, the term "yellowjacket" will be used collectively for yellowjackets and hornets. "Paper wasp" refers to species in the genus *Polistes*. See **TABLE 14.1** for characteristics that distinguish bees, wasps, and hornets.

IDENTIFICATION AND BIOLOGY

Yellowjackets

Yellowjackets are either black and white, black and yellow, or (in the case of the European hornet) dark red, brown, and yellow. Most species are medium-sized insects, although two commonly encountered species (baldfaced and European hornets) are some of the largest wasps in Pennsylvania. They are rapid fliers and hold their legs closer to their bodies than other wasps when in flight. Yellowjackets are generally more aggressive than other types of wasps. Their nests are always enclosed with a papery envelope and can be found in the ground, hanging from eaves or tree branches, and in wall voids and other cavities. Under the papery envelope, the nest is constructed in multiple tiers. Yellowjackets can be very aggressive, especially when the nest is disturbed.

Paper Wasps

Paper wasps are often darker shades of red, brown, and black, but they may be mostly yellow or light brown; the commonly encountered European paper wasp *(Polistes dominula)* is black and yellow and may be mistaken for a yellowjacket. Paper wasps are more slender than yellowjackets and have long, dangling legs in flight. Paper wasps construct open (i.e., lacks a paper envelope), single-tiered nests. They tend to be less aggressive than yellowjackets but can be provoked into stinging, especially when the nest is near a high-traffic area.

Table 14.1. Distinguishing Characteristics of Bees, Wasps, Yellowjackets, and Hornets

NAME	APPEARANCE	HABITS	NESTS	FEEDING BEHAVIOR
Social Bees (Honey Bees and Bumble Bees), see Figures A4–A8 on pages 35–36	Hairy, stout bodies with thick waists	Noisy flight; sting mainly while defending nest; foraging workers seldom sting	Honey bees: large nest in cavity (e.g., tree hollow, wall void); bumble bees: small nest in the ground or similar space (e.g., haystack)	Collect pollen and nectar; feed pollen to young and share food with other adults
Solitary Bees, see Figures A4–A6 and A9–A12 on pages 35–37	Hairy, stout bodies with thick waists	Not aggressive; may sting if provoked (e.g., handled, pinched)	Varies by species. In ground, hollow stems, tunnel into wood, holes in rocks or walls	Collect pollen to provision nest and feed young
Paper Wasps, **FIGURE 14.1**	Long bodies with thin waists, long dangling legs	Social; search vegetation for prey; visit flowers for nectar; not particularly aggressive	Single-layered, papery nests without an envelope; attached to fences, eaves, boards, branches; shaped like an umbrella	Beneficial predators, especially of caterpillars; feed prey to developing young in nest
Solitary Wasps, **FIGURE 14.2**	Thin- or thick-waisted	Visit flowers and other vegetation; generally docile	Varies by species. In ground, construct nests of mud on walls and rocks	Predators; provision nests with prey for young
Yellowjackets and Hornets, **FIGURE 14.3**	Stout, black and yellow or black and white	Rapid fliers; aggressive and capable of inflicting multiple stings; some species have large colonies, which they defend vigorously	Multilayered, papery nests surrounded by an envelope; nests built in ground or on structures or tree branches	Mostly beneficial predators, but scavenger species become pestiferous

Adapted from *IPM for Schools: A How-to Manual* (1997).

LEFT TO RIGHT: JUDY GALLAGHER, WIKIMEDIA; PHILLIP HARPOOTLIAN, BUGGUIDE.NET; BOB PETERSON, WIKIMEDIA; JIM MOORE, BUGGUIDE.NET

FIGURE 14.1. Examples of paper wasps and a paper wasp nest (from left to right): *Polistes metricus*, *P. exclamans*, *P. dominula*, and *P. major*.

A queen wasp begins a new nest by building a small comb of chewed wood. She lays eggs in the cells and, after the eggs hatch, tends the larvae herself. Once the larvae develop into adult workers, they expand the nest and take on the duties of foraging and tending young. In the late summer or early fall, males and new queens are produced. After mating, the queens seek a sheltered place to spend the winter and all the workers die. The nest is not reused and eventually disintegrates.

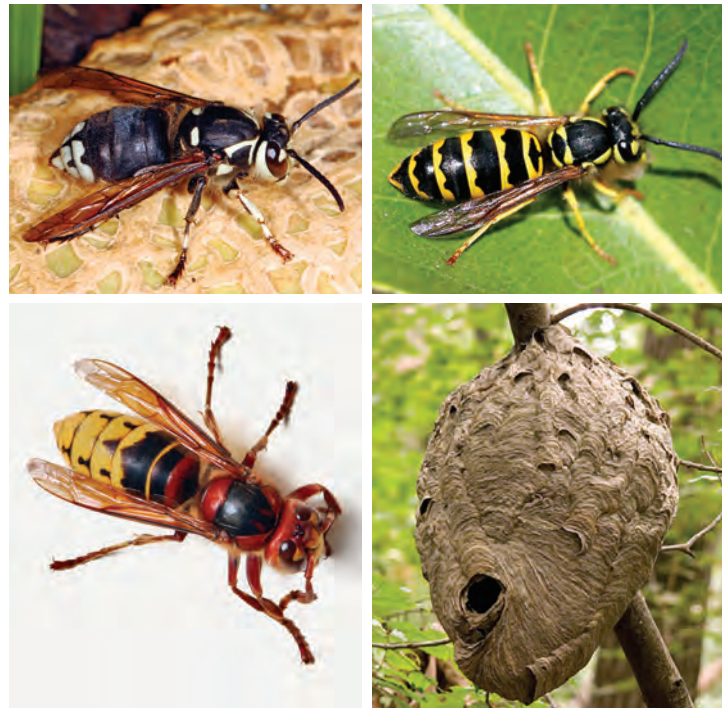
Early in the warm season, colonies are small and the wasps are usually not a problem. Later in the season, when colonies are at their peak, these insects can become pestiferous. Yellowjackets in the genus *Vespula* in particular search for protein and carbohydrate sources and are attracted to garbage cans, dumpsters, lunch counters, and playgrounds, where they scavenge for food.

NANCY HINKLE, UNIVERSITY OF GEORGIA, BUGWOOD.ORG

FIGURE 14.2. Cicada killer (*Sphecius speciosus*).

STINGS

Ordinary reactions to stings include localized pain, itching, redness, and swelling for hours to a day or two after the event. However, people who experience a large numbers of stings at once or suffer severe allergic reactions to stings may be at risk for heightened or severe reactions that may result in death. Signs of heightened or allergic reactions include soreness and swelling, not only at the site of the sting, but also on other parts of the body that may be distant from the site. Other signs include fever, chills, hives, joint and muscle pain, and swelling of the lymph glands and small air passageways. In severe cases, the individual may suffer a sudden drop in blood pressure and lose consciousness. While many individuals who experience allergic reactions have become sensitized over time by previous stings, half of all fatalities occur in individuals stung for the first time.



CLOCKWISE FROM TOP LEFT: JUDY GALLAGHER, FLICKR; PATRICK MURRAY, BUGGUIDE.NET; MICHAEL BATTENBERG, BUGGUIDE.NET; BERNIE KOHL, WIKIMEDIA

FIGURE 14.3. Examples of yellowjackets and hornets and an aerial nest (clockwise from top left): baldfaced hornet (*Dolichovespula maculata*), eastern yellowjacket (*Vespula maculifrons*), baldfaced hornet nest, European hornet (*Vespa crabro*).

NEST DISTURBANCE

Yellowjackets that are foraging for food will usually not sting unless physically threatened, such as being squashed or caught in a tight place (e.g., between skin and clothing). However, if they feel their nest is in danger, they will vigorously defend it. All wasps defend their colonies, but some yellowjackets are more sensitive to nest disturbance and more aggressive in their defense. Disturbing a yellowjacket nest can result in multiple stings. Sometimes merely coming near a nest, especially if it has been disturbed previously, can provoke an attack.

Underground nests can be disturbed simply by vibrations. Thus, mowing lawns or athletic fields can be hazardous, and operators may need to wear protective clothing when mowing during the late summer season when colonies are large. It can be very frightening to be the victim of multiple wasp stings. Aerial nests can be disturbed during shrub or tree pruning or building maintenance, especially if the nest is unseen beforehand. If there are only one or two wasps, back slowly away from them until they stop attacking you. Otherwise, it is best to run away from a colony rapidly, protecting your face and eyes as much as possible.

It is important to educate children about the beneficial role of these wasps (they feed on pest insects, particularly caterpillars) and remind them repeatedly of ways to avoid stings. Since problems with yellowjackets are most common in late summer and fall, teachers can be provided with this information at the beginning of the fall term.

See the box below for tips on avoiding and treating stings.

DETECTION AND MONITORING

If there is a chronic problem with yellowjackets around outdoor lunch areas or school athletic fields, inspect the area methodically to locate the nests. Nests can be found in the ground, under eaves, and in wall voids of buildings. Ground nests are frequently—but not always—located under

Avoiding and Treating Stings

Children should be taught to stay calm when confronted by a foraging yellowjacket because quick, jerky motions will frighten wasps and make them more likely to sting. Stillness or slow, gentle movements will greatly decrease the probability of being stung. Slowly and carefully brushing off a yellowjacket that has landed on someone or waiting until it flies off is better than hitting or constraining it, which will likely cause the yellowjacket to sting. Additionally, when crushed, yellowjackets give off an alarm pheromone that can cause other yellowjackets to attack.

If soft drinks, fruit juices, or other sweet and sticky beverages are being consumed on school grounds where there are many yellowjackets, warn children to look into their cups or cans before each sip because you can accidentally drink in a wasp and get stung in the mouth or throat. Tell them not to panic if they find a wasp taking a drink. Ideally, all sweet drinks should be in containers with secured lids. It may become necessary to prohibit eating and drinking outside during peak yellowjacket season.

First Aid for Stings

If the sting is to the throat or mouth, medical attention must be sought immediately because swelling in these areas can cause suffocation. **Dial 911 immediately** and give the victim an ice cube to suck.

For hypersensitive individuals:

- Anyone who is hypersensitive or has difficulty breathing and experiences wheezing, fainting, dizziness, or color changes (turning blue) should be treated by the school nurse and taken to a hospital emergency room immediately. If available, administer an epinephrine autoinjector (EpiPen). Otherwise, administer an antihistamine such as diphenhydramine (Benadryl) or loratadine (Claritin). The nurse should have an emergency kit containing preloaded syringes of epinephrine for use with hypersensitive individuals.
- Keep the affected portion of the body below the level of the victim's heart.

For all others:

- Wash the area around the sting with soap and water and apply an antiseptic. Washing can help remove the venom from the wound, which will help reduce the pain and swelling from the sting.
- As soon as possible, treat the sting with either ice contained in a cloth or plastic bag, or commercially available products for easing the pain of wasp or bee stings. Ice will help reduce the swelling, and the commercial products will relieve both pain and swelling. Some people claim a paste made of baking soda (sodium bicarbonate) helps reduce swelling and pain.
- Antihistamines given every few hours, according to label directions, can also prevent pain and swelling.
- Have the victim rest.
- Do **not** administer sedatives.

shrubs, logs, piles of rocks, and other protected sites. Entrance holes sometimes have bare earth around them. Nest openings in the ground or in buildings can be recognized by observing the wasps entering and leaving.

MANAGEMENT OPTIONS

The objective of a yellowjacket management program should be to reduce human encounters with the wasps, but not to eliminate them from the entire area since they are beneficial predators of insects. The two most productive and least environmentally destructive ways to do this are to modify the habitat to reduce yellowjackets' access to food in the vicinity of human activities, and to use physical controls such as trapping and nest removal. Area-wide poison baiting should be used only as a last resort when other methods have failed and stings are frequent.

Physical Controls

Habitat Modification

Garbage containers on school grounds should have tight-fitting lids. The cans should be emptied frequently enough to prevent the contents from impeding the closure of the lid. The lids and cans should be periodically cleaned of food waste. Disposable liners can be used and replaced when soiled or damaged. School garbage and the flies around it become a food source for yellowjackets in the area when these practices are not followed. If a large number of yellowjackets are around garbage containers, students may be afraid to get close enough to place garbage all the way inside, and spilled food will attract more yellowjackets. Dumpsters should be cleaned frequently by washing them with a strong stream of water. If the dumpster service company has a cleaning clause in their contract, make sure it is enforced.

To limit yellowjacket infestations inside school buildings, repair windows and screens and caulk holes in siding. Building inspections for yellowjackets can be done at the same time as inspections for other pests, such as rats, mice, and termites. Inspections should be conducted monthly to ensure developing nests are found before they get large enough to be problematic. Check fence posts, playground equipment, etc., for missing end caps and replace them because these open pipes can become harborages for stinging insects.

Trapping

There are a variety of traps on the market. Trapping with a sturdy trap and an attractive bait can significantly reduce yellowjacket numbers if a sufficient number of traps are used. In general, cone-type traps are more useful for long-term trapping that will last many weeks. In some schools, unbaited yellow sticky traps (like those used to catch whiteflies) affixed to fences near underground nests have provided sufficient management to protect children from stings.

A homemade cone-type fly trap can be used to catch yellowjackets simply by keeping the captured flies inside the trap as bait (see pages 82–83 for instructions on making the fly trap.) The yellowjackets enter the trap to get the flies and become trapped themselves (see the box below). If you use baits such as dog food, ham, fish, other meat scraps, or fermenting fruit and jelly, make sure the traps are placed in areas inaccessible to students because large numbers of yellowjackets may be attracted to the baits. However, the traps should be placed near the nest if it can be found and/or near the area where the yellowjackets are troublesome. Teachers or facilities managers can be instructed to make a short presentation on the purpose of the traps to satisfy the curiosity that students will undoubtedly have. Show students

Tips on Trapping Yellowjackets in a Homemade Cone-Type Fly Trap

Yellowjackets can be caught in a cone-type fly trap using only the trapped flies as bait. The following tips will help improve yellowjacket trapping:

- Use this trapping method where students cannot gain access to the traps or at a time when students are not in school.
- Mix the fly bait according to the instructions on page 84.
- Set up the fly trap with the fly bait in the area where the yellowjackets are a nuisance.
- If the trap is still attracting only flies after a day or two, move the trap to a new spot around the perimeter of the nuisance area.
- If your trap stops catching yellowjackets but is still catching flies, try switching to a sweet bait such as fruit punch or jam.

Note: To avoid being stung, you should replenish the bait or move the trap in the cool parts of the day (early morning or late evening). To kill everything in the trap before emptying it, put the trap into a large plastic garbage bag and seal the bag. Place the bag in direct sunlight for several hours or in a freezer overnight or submerge the traps in a bucket of soapy water until the wasps drown.

the traps, explain how they work, and stress the importance of the traps in maintaining the safety of the playground. Then be sure to move the traps to an area inaccessible to students.

When traps are full they can be placed in a freezer for a day to kill the wasps, enclosed in a heavy-duty plastic garbage bag and placed in the direct sun for several hours, or submerged in a bucket of soapy water until the wasps drown. The traps should be out only during the period that yellowjackets are a problem, usually late summer and early fall. When the traps are taken down for the year, they should be cleaned with soap and water, dried, and stored.

Nest Removal

A nest can be destroyed through physical removal (vacuuming) or by using a pesticide (see "Chemical Controls" below). Either way, great care must be exercised because any disturbance around a nest can cause multiple stings. It is best to have a pest management professional or other experienced person remove the nest. Nest removal should take place at night when the children are out of school and the yellowjackets are in the nest. When illumination is needed, use a flashlight covered with red acetate film so it will not disturb the wasps. Adequate protective clothing and proper procedures can minimize problems and stings. It is important to wear protective clothing when removing wasp nests. Complete body coverage is essential because yellowjackets and other wasps can find even the smallest exposed area. Use clothing and gear made for beekeepers, including:

- A bee veil or hood that either contains its own hat or can be fitted over a lightweight pith helmet or other brimmed hat that holds the veil away from the head. A metal-screen face plate that extends around the head is a desirable feature. Check the veil carefully for tears before each use.
- A bee suit or loose-fitting, heavy-fabric coverall with long sleeves. This is worn over regular pants and a long-sleeve shirt to provide extra protection from stings.
- Sturdy, high-topped boots. Secure pant legs over the boots with duct tape to prevent wasps from getting into trousers.
- Gloves with extra-long arm coverings so sleeves can be taped over them to protect the wrists.

Vacuuming

Vacuuming out entire nests is not recommended unless it is done by a pest management professional experienced in handling stinging insects. Vacuuming is particularly effective when nests occur in wall voids, for emergencies where nests have already been disturbed, and in environmentally sensitive areas where nests should not be treated with insecticides. Some pest management professionals in some cities will perform this service for free so they can collect the wasps to sell to pharmaceutical companies for their venom. If the school is interested in this option, take time to find a company that will perform this service for you.

Chemical Controls

If nonchemical methods prove insufficient to solve the problem, then integrating a pesticide into your management program may be warranted. Pesticides must be used in accordance with their EPA-approved label directions, including that it is labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and Safety Data Sheets (SDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label. **Pennsylvania law allows pesticide applications in schools and childcares only by certified applicators, registered technicians, or noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must also be posted on school grounds at the place to be treated at least 72 hours prior to and for 48 hours after the application. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied on school grounds and students are expected to be in the immediate vicinity for normal academic instruction or extracurricular activities.**

When an insecticide is considered necessary for the management of yellowjackets, the best approach is to confine it to the nest itself. Anyone applying insecticides should use special clothing that protects against the chemical and wasp stings. Insecticides should be applied in the evening or very early morning when children are absent, the wasps are inside the nest, and cooler temperatures reduce insect activity.

A number of insecticides are registered for use

against yellowjackets. Silica aerogel and pyrethrins are the most appropriate for use in schools. Silica aerogel combined with pyrethrins is an effective insecticidal dust that can be used to destroy an underground nest or a nest in a wall void. Silica aerogel is made from sand and works by abrading the outer waxy coating on insect bodies. Once this coating is damaged, the insects cannot retain water and die from dehydration.

Products with Components That "Freeze" Wasps

Pyrethrins can be used to quickly knock down guard wasps at the nest entrance and kill yellowjackets in an aerial nest when they must be destroyed in the daytime. These aerosol products are designed to project a stream of spray 10 to 20 feet and contain highly evaporative substances that "freeze" or stun the yellowjackets.

Do Not Use Gasoline

Gasoline should never be poured into underground nest holes. This dangerous practice creates a fire hazard, contaminates the soil, and prevents the growth of vegetation for some time. **A ground application of gasoline poses greater harm to children and the environment than a yellowjacket nest.**

Avoid Area-Wide Control Measures

Mass control measures are seldom, if ever, necessary, and they are expensive due to the labor involved in the frequent mixing and replacement of bait. The effectiveness of bait mixtures is also questionable since the baits face considerable competition from other food sources that are more attractive to scavenging yellowjackets.

Integrated Pest Management for Plant Pests

IPM for School Lawns

INTRODUCTION

School lawns often cover several acres and serve important roles as athletic fields, picnic lunch sites, outdoor classrooms, and general recreational areas for the community at large. Heavy use of lawns and athletic fields causes stress that predisposes grass to attack by a variety of weeds, pest insects, pathogens, and vertebrates such as moles. As a result, most pesticides used on school grounds are applied to lawns and athletic fields. Because the bodies of children and youth are often in direct contact with the grass, using pesticides on lawns increasingly raises concerns among parents and health professionals. On the other hand, coaches and school administrators are under pressure to ensure quality turf for use by students and community athletic leagues. In addition, the competence of landscape maintenance staff is often judged by the aesthetic appearance of the lawns that surround most schools. These various viewpoints often come into conflict when pests threaten lawns and athletic fields.

The key to lawn IPM is regular scouting. Cultural practices that optimize growth of grasses and minimize conditions favorable to pest insects, weeds, or pathogens are vital to an IPM program. Since specific methods for managing all possible lawn pests is beyond the scope of this chapter, a general IPM approach is described, followed by complete management programs for a typical lawn pest, chinch bugs.

Tools Used to Monitor Lawns

The following tools are useful for monitoring lawns. They can be carried in a sturdy bag designed to transport baseball equipment (available at most sporting goods stores). The soil probe with its extension fits snugly in the bottom pocket designed for baseball bats, and everything else fits into an upper zippered area.

- Soil probe
- pH meter
- Soil thermometer
- 10× hand lens (magnifying glass)
- Watering can and bottle of detergent
- Plastic bags for collecting specimens
- Clipboard and forms for recording data
- Ball of twine or clothesline for taking transects
- Small hand trowel and knife
- Camera
- Field guides for identifying pests and natural enemies
- Pheromone traps for cutworms, sod webworms, and other pests

DETECTION AND MONITORING

An IPM approach to lawn management begins with a monitoring program. Monitoring entails making **regular** inspections of the lawn to gather and record site-specific information on which to base pest management decisions. Monitoring enables pest managers to do the following:

- Identify the pest(s).
- Identify any natural enemies of the pest(s).
- Apply preventive methods to reduce the occurrence of pest problems.
- Determine if any treatment is needed.
- Determine where, when, and what kind of treatments are needed.
- Evaluate and fine-tune treatments as the pest management program continues over the seasons.

BACKGROUND INFORMATION ON LOCAL PESTS

When beginning a monitoring program, some effort should be made to become familiar with the common pest insects, weeds, and lawn pathogens in the local area. Learn about their life cycles and how to recognize them. **TABLE 15.1** lists common lawn pests in Pennsylvania along with websites that provide more information about each. Additional information can be obtained from the Penn State Extension office in your county. It also is important to learn to recognize the natural enemies of common lawn pests and factor their presence into deciding if treatments are needed and which ones to use.

Table 15.1. Common Pennsylvania Turf Pests and Websites

Common Name	Scientific Name	Website for More Information
Ant (Nuisance)	Formicidae spp.	https://ento.psu.edu/extension/factsheets/ants-lawns
Asiatic Garden Beetle	*Maladera castanea*	https://extension.unh.edu/resources/files/Resource000542_Rep564.pdf
Black Cutworm	*Agrotis ipsilon*	https://entomology.unl.edu/turfent/documnts/cutworms.shtml
Black Turfgrass Ataenius	*Ataenius spretulus*	http://ipm.ucanr.edu/PMG/r785300511.html
Bluegrass Billbug	*Sphenophorus* spp.	https://ohioline.osu.edu/factsheet/HYG-2502-12
Diagnosing Turfgrass Problems		https://extension.psu.edu/diagnosing-turfgrass-problems
European Chafer	*Rhizotrogus majalis*	http://msue.anr.msu.edu/resources/european_chafer_tips_for_your_lawn
Green June Beetle	*Cotinis nitida*	https://ento.psu.edu/extension/factsheets/green-june-beetle
Hairy Chinch Bug	*Blissus leucopterus hirtus*	https://ohioline.osu.edu/factsheet/HYG-2503-11
Japanese Beetle	*Popillia japonica*	https://ohioline.osu.edu/factsheet/ENT-46
May/June Beetle	*Phyllophaga* spp.	https://trec.ifas.ufl.edu/mannion/pdfs/May-JuneBeetle.pdf
Northern Masked Chafer	*Cyclocephala* spp.	https://ohioline.osu.edu/factsheet/ENT-51
Oriental Beetle	*Exomala orientalis*	http://cues.cfans.umn.edu/old/Web/247OrientalBeetle.pdf
Sod Webworm	Crambinae spp.	https://ento.psu.edu/extension/factsheets/sod-webworms-lawns
White Grub in Turfgrass	Scarabaeidae	https://ohioline.osu.edu/factsheet/hyg-2510 https://ento.psu.edu/extension/factsheets/white-grubs-lawns

GATHERING BACKGROUND DATA ON THE SITE

The next step in a monitoring program is to map all lawn areas, noting locations of existing pest problems or conditions that can produce pest problems, such as bare spots or broken sprinkler heads. Identify the lawn grasses in each area and record the maintenance history of the turf and current horticultural practices. Soil should be tested at representative sites to assess fertility status and requirements. If any pest organisms are present, be sure to get an accurate identification. Many unnecessary pesticide applications can be traced to mistaken identification of pests. Then, give each major section of lawn an identifying number. Prepare a monitoring form for recording ongoing maintenance activities and information about pests and their management in each section. You will need to compile an inventory of existing lawn maintenance equipment. In addition to mowers, do you have an aerator, dethatcher, and fertilizer spreader that can handle organic materials? Is there a spring-tooth harrow for removing weeds from infields and running tracks? These are useful tools in nonchemical lawn management. Inspect the condition of the equipment, too. Are mower blades kept sharp? Can mowing height be adjusted easily? Does the equipment have flotation tires to reduce soil compaction? Prepare a list of equipment needs so they can be worked into the budget process.

DEVELOPING PEST TOLERANCE LEVELS

Most lawns can tolerate some pest presence without compromising appearance or function. The challenge for the pest manager is to determine how much damage is tolerable and when action is needed to keep pest damage within tolerable levels. Since the users of the lawn must be taken into account when deciding whether or not treatments are warranted, it is a good practice to involve representatives of these interest groups in setting pest tolerance levels for lawn areas.

One approach is to work with an IPM advisory committee to develop pest tolerance levels for lawns at each school site. Tolerance levels will differ depending on location and uses of the lawns. For example, tolerance for pest presence on lawns at the front of the school in public view may be lower than tolerance for playing fields behind school buildings. Tolerance levels may also differ depending on the particular pest. For example, tolerance for damage by pest insects or pathogens that can kill large areas of turf, leaving bare soil, may be lower than tolerance for weeds that displace grasses but nevertheless continue to cover soil and serve as a playing surface. Tolerance levels can be quantified in a number of ways. The "Transect Method for Monitoring Weeds in a Lawn" (see box on the following page) describes a method for quantifying the amount of weeds growing in a lawn. This permits expression of tolerance levels by percentage of weeds. For example, "Up to 25 percent weed growth is tolerable on the back lawn at the elementary school; only 10 percent is tolerable on the football field at the high school."

It is important to note that PDA administers the Noxious Weed Control Law and Noxious Weed Control List. Plant identification and information about the noxious weeds list is maintained by PDA. If the weeds of concern are on the Pennsylvania Noxious Weeds Control List, then they must be suppressed, controlled, or eradicated based on the current priority class. More information regarding this list can be found on the PDA website by searching "Noxious, Invasive and Poisonous Plant Program" or by contacting your nearest PDA Regional Office.

Tolerance for insect damage can be correlated with numbers of insects present and amount of visible damage. For example, white grubs can be monitored by examining several areas of soil underneath the grass. A spade is used to cut three sides of a 1-foot square of grass. The grass is carefully folded back, using the uncut edge as a hinge. Soil from the roots is removed, and the number of exposed grubs is counted. Then the grass can be folded back into place, tamped, and watered in. In well-managed lawns, depending on the species, up

The Transect Method for Monitoring Weeds in a Lawn

1. At the beginning and end of the season, establish three parallel transect lines along the length of the field. Use the center of the field and two imaginary lines on either side. **Note:** Three transects will give sufficient data to indicate the percentage of weed cover in the total turf area. If time is limited, information recorded from one transect across a representative area of turf (for instance, down the center of the field) may give sufficient indication of weed trends for management purposes.
2. Calculate the number of paces you will walk between samples.
   a. Measure the length of one of your transect lines in feet (e.g., 360 feet).
   b. Measure the length of the pace of the person doing the transect. To do this, slowly walk a known length (e.g., 20 feet), count the number of paces it takes to cover this distance (e.g., 10 paces), and divide the distance by the number of paces (20 feet ÷ 10 paces = 2 feet per pace). This figure represents the average length of the pace.
   c. Divide the length of the field by the length of the pace (360 feet ÷ 2 feet per pace = 180 paces). This establishes the number of paces it takes to walk the transect.
   d. Divide the number of paces by the number of samples to be recorded (a minimum of 20 samples is recommended): 180 paces ÷ 20 samples = 9 paces per sample. Thus, in this example, a sample will be taken every ninth pace along the transect.
3. Stretch lines of string along the three transect lines, laying the string directly on the ground.
4. Beginning at one end of the first transect, walk the calculated number of paces (9 paces in the above example), stop and look at a 3-by-3-inch area (this is about the circumference of a softball or the lid to a 1 pound coffee can) immediately in front of your toe. If this area contains part or all of a weed, check the "yes" box on the first line under "Transect A" on the monitoring form (see the following page). If you know the identity of the weed, write it down. If the toe sample area contains grass, check the "no" box on the monitoring form. If 25 percent or more of the toe area sample is bare soil, check the box marked "bare." If less than 25 percent is bare, but a weed is present, check "yes." Continue pacing the transect line and marking the monitoring form. Repeat along the two other transect lines.
5. To calculate the average percentage of weeds, total the number of boxes marked "yes" in each column and multiply by 100. Divide this number by the total boxes in all columns. The resulting figure represents average percent weed cover in the turf. Do the same calculation with the boxes representing bare ground. This will indicate percent area that will become weedy if not seeded to grass.
6. By collecting data from the transects at the beginning and end of each season, the turf manager can spot emerging problem areas. For example, if several boxes in succession are marked "yes," indicating weed presence, a closer look at this area on the transect is warranted. Usually such "clumping" of weed growth indicates exceptionally heavy wear on the turf, although structural problems, such as severely compacted soil, a broken irrigation line, inoperative sprinkler head, or scalping of the turf due to uneven grade, may also be indicated.

By monitoring the turf area from season to season, the manager can tell if weed populations are rising, falling, or remaining relatively stable. This information will indicate whether or not current turf management practices are keeping weeds at or below the agreed-upon tolerance level. If weed populations are rising, changes in management practices are indicated.

Weed Monitoring Form for Turf

Sketch of location of transects

Location of turf _____ Date _____

Data collected by _____ Length of pace _____

Distance between sampling points on transect _____ *(for example, every nine paces)*

Number of transects _____ Length of transects _____

	TRANSECT A				TRANSECT B				TRANSECT C			
	Yes	**No**	**Bare**	**Weed ID**	**Yes**	**No**	**Bare**	**Weed ID**	**Yes**	**No**	**Bare**	**Weed ID**
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												

Average % weed growth _____ Average % bare area _____

Total the number of boxes marked “yes” in each column. Multiply this number by 100 and divide by 60 (the number of samples taken).
The result is the average percentage of weeds growing in the turf area. Follow the same procedure to calculate percentage of bare area.

to 15 grubs per square foot can be present without causing any appreciable damage to the turf. In stressed or poorly managed lawns, however, 15 grubs per square foot might seriously damage the grass. By setting tolerance levels, pest managers and groundskeepers can gear their management efforts toward keeping pest populations within tolerable levels, and apply treatments only if, when, and where necessary. Involving members of the school and community in setting treatment guidelines can minimize confrontations and help develop broad support for the IPM program.

EVALUATING PEST MANAGEMENT PRACTICES

When actions are taken to reduce pest presence, monitoring data should be used to evaluate the effectiveness of the treatment. Did pest numbers go down sufficiently to prevent intolerable damage? Were treatments cost-effective? Is the problem likely to recur? Can conditions causing chronic pest problems be altered or removed? If not, can other groundcovers better suited to site conditions replace the lawn?

MANAGEMENT OPTIONS

When pest numbers threaten to exceed tolerance levels (in other words, when the action level is reached), many strategies and tactics are available to solve any lawn pest problem. The first approach is to address conditions causing stress to lawns.

Stress and Pests

The pest problem of greatest concern on school lawns—and the target of highest pesticide use—is the growth of weeds, such as dandelions (*Taraxacum officinale*) or crabgrass (*Digitaria* spp.). Presence of weeds is a symptom of a lawn undergoing stress or poor management, a common occurrence on school lawns and athletic fields. Lawn stress can contribute to the development of insect and disease problems as well. Sources of stress include levels of use unsuited to the grass species that has been planted, compacted soils, improper mowing heights, too much or too little irrigation or fertilization, accumulation of thatch, and uneven grading.

Knowing the identity of the pest and something about its biology often reveals the specific source of stress. Relieving the stress can reduce or eliminate the pest problem. For example, the weed yellow nutsedge (*Cyperus esculentus*) often grows in waterlogged soils, so its presence could indicate a faulty or broken irrigation valve or a low spot in the lawn. The presence of chinch bug (*Blissus* spp.) damage, on the other hand, indicates drought stress. Brown patch disease, caused by the fungus *Rhizoctonia solani*, suggests excessive fertilization with soluble nitrate or slow-release fertilizers, especially during hot, wet conditions.

The best way to reduce stress on lawns is to use good horticultural practices during lawn installation and maintenance. Even where budgets are limited, key sources of stress can be avoided or diminished by minor changes in maintenance practices, such as raising the mowing height or changing fertilizer formulations. The following lawn care suggestions will help keep pest problems to a minimum.

Maintaining Healthy Soil

The most vigorous lawn growth occurs in loose, loamy soils teeming with beneficial microorganisms, insects, worms, and other organisms. These organisms play critical roles in transforming thatch and grass clippings into humus. Humus slowly releases nutrients and buffers grass roots from extremes of drought or other stresses. Soil organisms also play an important role in biological pest management. For example, certain beneficial microorganisms protect lawn roots from attack by soil pathogens or insects such as white grubs. The presence of humus in the soil is key to a healthy soil ecosystem. One way to improve poor soils and maintain healthy soils is to ensure organic matter is routinely replenished by leaving grass clippings to decompose and fertilizing or topdressing with organic materials such as sludge or composted manure. To prevent buildup of an organic layer, the organic material can be incorporated into the soil using an aerator equipped with hollow tines and a heavy drag mat attached. This operation is best performed during cool, moist seasons when grass is actively growing. On smaller areas, a grass rake can be used to incorporate the materials.

Planting Appropriate Grass Species

School lawns are subject to high levels of use and wear, and maintenance budgets are usually low, so it is important to select blends of grass species tolerant to such conditions and resistant to local pest problems. The Penn State Extension office in your county can recommend grass species suited to local climate and conditions. In Pennsylvania, tall fescue (*Festuca arundinacea*) is recommended for most school situations.

Reducing Soil Compaction

When lawns are heavily used, or simply mowed on a regular basis, the soil eventually becomes compacted, and the pore spaces that allow water and air to pass through the soil become compressed, creating adverse conditions for root growth. Compaction can be reduced through core aeration and amending soils with organic matter. Core aeration involves removing plugs of grass to improve air exchange and water penetration into the soil. Ideally, heavily used turf should be aerated at least two times per year, although even a single aeration is better than none. After aeration, and before seeding the desired lawn grass, drag the lawn with a heavy drag mat to break up cores of soil left by the aerator and fill in holes. Mowers and other maintenance equipment compact the soil. By rotating the point of mower entry onto the lawn from week to week, compaction at entry points can be minimized.

Increasing the Mowing Height

Most temperate grasses used on school lawns (tall fescues, perennial ryes, bluegrasses, and others) can be mowed at a height of 2½ to 3 inches without sacrificing vigor or function as ball fields or recreational areas. The taller the grass can be kept and the denser the canopy, the greater the interception of available sunlight. Because taller grass shades the soil, weed seeds are less likely to germinate. Adjust mowing frequency to changes in the growing season. Weekly intervals may be appropriate when grasses are growing vigorously, but when grasses are semidormant, 14 days or longer may be more appropriate. The right interval between mowings allows grasses to recover from the previous cut.

Careful Irrigation

Too much or too little water stimulates pest problems. For example, many lawn diseases result from excessive irrigation. Development of a disease can often be arrested by letting the lawn dry out, then keeping irrigation to a minimum. On the other hand, chinch bugs require hot, dry conditions for optimal survival and reproduction. Irrigation during the spring and early summer may increase the incidence of pathogen spread, especially the lethal fungus *Beauveria* spp. The adults can withstand water because of the protective hairs on their body, but the nymphs readily get wet and can be damaged by large water droplets.

The length of time needed to adequately water lawns is determined by the time it takes to wet it to the depth of the root system. Most lawn grass roots extend 4 to 6 inches in the soil, but because grasses and soil conditions differ, irrigation schedules must be tailored to individual lawns and adjusted for seasonal changes. Infrequent, deep irrigation is best since frequent, shallow watering promotes shallow rooting. Use a soil probe or a pointed tool, such as a screwdriver, to determine when soil is wet 4 to 6 inches below the soil. This will indicate how long to leave sprinklers on at each irrigation. Irrigation equipment should be checked to ensure it is in good repair and that all areas of the lawn receive adequate coverage. Low spots should be leveled or drained to avoid waterlogged soils that favor weeds and pathogens.

Keeping Thatch to a Minimum

Thatch is the accumulation of dead but undecomposed roots and stems that collect in a layer at the soil surface. If the thatch becomes excessively deep (greater than ¾ inch), then water and nutrients do not penetrate the soil adequately. When water puddles on thatch, it enhances the habitat for disease organisms. Regular aeration keeps thatch at an acceptable level. Excessive nitrogen applications may result in organic matter production rates that exceed breakdown, encouraging thatch accumulation. Excessive layers of thatch can be removed with dethatching rakes or power dethatchers, available from equipment rental companies. It is wise to seed the area with desired grasses wherever lawns are thinned by dethatching procedures.

Fertilizing with Restraint

Excessive nitrogen fertilizer produces weak grass that is susceptible to disease attack. A soil test should be obtained before planning annual fertilization programs. Only the levels of nutrients needed should be applied. Split applications (one in spring, one in fall) should be used rather than a heavy single application in the spring. Use slow-release fertilizer to prolong the availability of nutrients throughout the growing season. Fertilization can be used to directly suppress weeds and lawn pathogens. A study by Ohio State University Extension Service researchers in the 1940s showed that an application of 20 pounds of composted poultry manure per 1,000 square feet of lawn in late fall and early spring stimulated early spring growth of lawn grasses, enabling them to crowd out crabgrass. In this study, crabgrass was reduced by up to 75 percent within one year.

DIRECT PEST SUPPRESSION

When the horticultural methods listed above are not sufficient to solve the pest problem, direct suppression methods, including physical/mechanical, biological, and chemical tactics, can be integrated into the program. Physical/mechanical controls include hand pulling selected weeds or mowing to prevent seed dispersal from unwanted plants prior to reaching maturity. For more detailed information regarding weeds, search Penn State Extension for the "Weed Management in Turf" manual or contact the extension office in your county. Biological controls include applying microscopic, insect-attacking nematodes to kill soil-dwelling white grubs, or topdressing lawns with microbially enhanced soil amendments to kill lawn pathogens. Chemical controls are available. Check with the Penn State Extension office in your county for information about pesticides appropriate for your pest problems. Pesticides (including herbicides) must be used in accordance with their EPA-approved label directions, including that it is labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and Safety Data Sheets (SDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label. **Pennsylvania law allows pesticide applications in schools and childcares only by certified applicators, registered technicians, or noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must also be posted on school grounds at the place to be treated at least 72 hours prior to and for 48 hours after the application. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied on school grounds and students are expected to be in the immediate vicinity for normal academic instruction or extracurricular activities.**

IPM Plan for Hairy Chinch Bugs

DAVID SHETLAR, THE OHIO STATE UNIVERSITY, BUGWOOD.ORG

FIGURE 15.1. Hairy chinch bug adult.

Hairy chinch bugs (*Blissus leucopterus hirtus*) are the most important of the "true bugs" (order Hemiptera) that become pests on lawns **(FIGURE 15.1)**. Heavily infested areas may contain as many as 200 to 300 chinch bugs per square foot.

IDENTIFICATION AND BIOLOGY

Adult chinch bugs overwinter in dry grass and other debris that offers them protection. In spring or early summer, depending on temperature and moisture, overwintering females lay from 200 to 300 eggs on leaves of grass or push them into soft soil and other protected places. Young nymphs (the immature stages) emerging from the eggs are bright red with a distinct white band across the back. The red changes to orange, orange-brown, and then black as the nymph goes through five growth stages in 30 to 40 days. Nymphs range from about 1/20 inch soon after hatching to nearly the size of the ¼-inch-long adult **(FIGURE 15.2)**. The nymphs mature into adults, which are black with a white spot on the back between the wing pads.

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FIGURE 15.2. Life stages of hairy chinch bug.

DAMAGE

Chinch bugs suck the juices from grass leaves with their needlelike mouthparts. They also inject toxic saliva into the plant that disrupts the plant's water-conducting system, causing it to wilt and die. Most damage is caused by nymphs and adults concentrated in limited areas and feeding on the same plants until all the available juice has been extracted from the grass. This feeding pattern results in circular patches of damaged grass that turn yellow and then brown as they die. In the yellow stage, the grass superficially resembles grass that is drought stressed. As it dies, the chinch bugs work outward from the center of the infestation, destroying a larger area as they advance. Populations of chinch bugs increase under hot, dry conditions. In wet, cool years or when lawns are kept properly irrigated and not overfertilized, chinch bug populations decrease significantly because the moisture encourages the growth of the lethal fungus *Beauveria* spp., a pathogen of chinch bugs.

DETECTION AND MONITORING

Lawns can be protected from damage by chinch bugs through regular monitoring. The objective is to detect pests while their populations are still small and determine whether their natural controls—such as adverse weather, other insects, and diseases—will keep the population low enough to prevent damage. Any lawn can tolerate a low population of chinch bugs and most other pests without sustaining significant damage. If the monitoring techniques described below indicate that there are fewer than 10 to 15 chinch bugs per square foot, then generally, no action is needed.

It is a good idea to begin monitoring as early as mid-May, before overwintering adults have finished laying their spring eggs. A quick check of the lawn once a month until September should be sufficient in most areas. Since nymphs tend to congregate in groups, it is important to check several areas of the lawn. Infestations often begin

on the edges of lawns, particularly in sunny, dry spots, so check these areas carefully. Spread the grass apart with your hands and search the soil surface for reddish nymphs or black adults. Chinch bugs may also be seen on the tips of grass blades, where they climb to during the day. Be certain to distinguish between the chinch bugs and their predator, the big-eyed bug, which they superficially resemble **(FIGURE 15.3)**.

A second detection method requires a metal container (such as a coffee can) with both ends removed. Insert this can into the ground and fill it three-quarters full with water. Stir the duff at the bottom of the container. Count the number of adults and nymphs floating to the surface over a period of 10 minutes. Repeat this procedure in three to five locations in the lawn where damage is present or in adjacent areas.

MANAGEMENT OPTIONS

Physical/Mechanical Controls

Chinch Bug–Resistant Grass Cultivars

If chinch bugs are a chronic problem, it may be advisable to replace existing grass with a type that is resistant to chinch bugs. Endophyte-enhanced grasses may be used to repel insect pests. An endophyte is a fungus that grows inside a plant, and research has shown that turfgrass species containing endophytes have enhanced resistance to surface-feeding insects, including chinch bugs, sod webworms, and billbugs. Try perennial ryegrass varieties such as 'Repell' or 'Score' or a Kentucky bluegrass variety such as 'Baron'.

Habitat Management

Chinch bugs are attracted to lawns that have an excessive buildup of thatch, are insufficiently irrigated (often due to soil compaction), or have either too little or too much nitrogen. The discussion on good lawn culture provided on pages 160–161 includes suggestions on overcoming these problems. Proper habitat management will go a long way toward suppressing these bugs.

Manual Removal

Small populations of chinch bugs can be removed from the lawn using the soap solution and white flannel cloth method described in the box to the right. This is particularly appropriate when damage is just beginning to appear since at this stage chinch bug nymphs are still congregated in specific locations and can be collected efficiently. Small vacuums may also be helpful.

PAUL LANGLOIS, MUSEUM COLLECTIONS: HETEROPTERA, USDA APHIS PPQ, BUGWOOD.ORG

FIGURE 15.3. Big-eyed bug.

Biological Controls

One of the primary tactics for the biological control of chinch bugs is conserving its natural enemies. At least two beneficial organisms often move in to feed on chinch bugs: the big-eyed bug and a tiny wasp. The big-eyed bug (*Geocoris* spp.) superficially resembles a chinch bug, so pest managers must learn to distinguish between the two. According to Ohio State University turf specialist Harry Niemczyk (1981), "The body of the chinch bug is narrow, the head small, pointed, triangular-shaped, with small eyes, while the body of the big-eyed bug is wider, the head larger, blunt, with two large prominent eyes. Big-eyed bugs run quickly over the turf surface and are much more active insects than the slower-moving chinch

Soap and Flannel Trap Method for Chinch Bugs

Put 1 fluid ounce of dishwashing soap in a 2-gallon sprinkling can and drench a 2-square-foot area of lawn where you suspect there are chinch bugs. Watch the area for 2 or 3 minutes. Larger areas can be covered by putting the detergent in a hose attachment designed to hold pesticides for spraying the lawn. If chinch bugs are present, they will crawl to the surface of the grass. Next, lay a piece of white cloth, such as an old bedsheet or a piece of white flannel, over the area treated with the soapy water. Wait 15 to 20 minutes, then look under the cloth to see if chinch bugs have crawled onto it as they attempt to escape the soap. Their feet tend to get caught in the flannel's nap. Pick up the cloth and either vacuum it or rinse it off in a bucket of soapy water to remove the bugs. The vacuum bag should be disposed of so that the bugs will not return to the lawn.

This method can also be used to monitor for other insects such as lawn caterpillars, mole crickets, and beneficial insects that feed above the soil, but it will not bring soil-inhabiting grubs or pillbugs to the surface.

bugs." Big-eyed bugs are commercially available from a few online biocontrol suppliers.

Chemical Controls

If nonchemical methods alone prove insufficient to solve the problem, then integrating a pesticide into your management program may be warranted. Pesticides must be used in accordance with their EPA-approved label directions, including that it is labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and Safety Data Sheets (SDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label. **Pennsylvania law allows pesticide applications in schools and childcares only by certified applicators, registered technicians, or noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must also be posted on school grounds at the place to be treated at least 72 hours prior to and for 48 hours after the application. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied on school grounds and students are expected to be in the immediate vicinity for normal academic instruction or extracurricular activities.** If pesticide use seems necessary to bring a serious chinch bug infestation under control, insecticidal soap or pyrethrin should be considered.

IPM for Trees and Shrubs

INTRODUCTION

Landscapes vary so greatly that it would be impossible to provide specific management suggestions for all the pest problems on the many trees and shrubs that might be encountered on school grounds. Instead, we will try to provide a basic framework that will enable you to solve your own problems using information from your specific site.

PLANT HEALTH CARE MANAGEMENT

Plant health care management (PHC) is a concept in managing landscapes that was developed from the concept of integrated pest management. Many arborists, horticulturists, and landscape managers have long felt that IPM's focus on "pests" is too narrow when applied to landscape plants. More than half of the problems encountered in landscapes or gardens are probably not caused by insects, mites, or disease; instead, they are the result of compacted soil, drought stress, overwatering, frost damage, and many other factors. To manage landscapes effectively, plant health and the ecosystem in which the plant is growing must be taken into consideration. PHC takes just this kind of broad approach. PHC incorporates all the principles of IPM, including monitoring, recordkeeping, and integrating treatments, but PHC emphasizes plant health and proper horticultural practices. PHC is plant management, not just pest management. By focusing only on pests, we often overlook the horticultural or environmental factors that affect plant growth and health.

Components of a PHC Program

Van Bobbitt (1994) lists the following five components of a PHC program, which are explained in detail below:

1. Know your plants.
2. Determine key problems.
3. Study your landscape ecosystem.
4. Promote plant health.
5. Consider a variety of strategies to manage pests.

Know Your Plants

Before you can properly care for the trees and shrubs on your school grounds, you must know what they are. Make a map of the grounds and identify every tree and shrub. Many books are available to help with this, or you can take a specimen to a nursery, the Penn State Extension office in your county, or a landscaping professional.

Once you know the names of all your plants, do some research on each one. Talk to nursery personnel and horticulturists and read about your plants in gardening books or online university resources. From your research, you should be able to answer the following questions:

- What kind of soil does the plant prefer?
- How much water does it need?
- When should it be fertilized?
- How should it be pruned?
- Does it prefer shade or sun?
- How much heat or cold can it tolerate?
- What are its most common pest problems?
- What environmental problems—soil compaction, air pollution, salt damage, and others—is it susceptible to?
- Is there too wide of a span with the same plant/polyculture situations? These allow for easy spread of pest species with preferences for target plants.

It may be helpful to write standardized notecards, spreadsheets, or information sheets so these details are readily accessible. Your research and experience can help you identify key plants that are prone to problems and need more of your time and attention than other plants. If there are many trees and shrubs on the school grounds, this information can help you focus your maintenance activities. You may also want to use this information to remove plants that are not suited to their sites, have too many problems, or require too much care.

Determine Key Problems

Many things affect the health of a tree or shrub. They are generally divided into biotic factors and

abiotic factors. Biotic factors are living organisms, such as diseases, insects, mites, and deer. Abiotic factors include maintenance practices (fertilizing, pruning, irrigation), weather, soil quality, amount of sunlight, and human activities such as vandalism or soil compaction caused by foot traffic. These abiotic factors are likely responsible for the majority of landscape plant problems.

Determining the key problems affecting your landscape plants involves deciding which situations or factors are most likely to affect the health of your plants. Ask yourself if the problem is a serious threat to plant health, a minor threat, or just an aesthetic problem. For instance, one plant disease may kill a tree, while another disease may cause premature leaf drop year after year without seriously affecting tree health. If the problems are caused by living organisms, learn about their life cycle, how to identify various stages of the pest, and how to recognize symptoms of damage. Do enough research to help you decide which management options are both safe and effective. If the problems are caused by abiotic factors, are there specific symptoms that you can learn to recognize? What techniques are available for solving the problem? Which solutions can you afford, and which are best suited to the particular site? Are there specific plants that can tolerate the abiotic factors?

It is likely that you will encounter key problem sites in addition to key problems. For example, perhaps the heavy equipment used in remodeling the school last year severely compacted the soil in several areas, or perhaps drainage is poor in one corner of the school yard because of heavy clay soil. These sites will need special attention and most likely special plants, too.

Study Your Landscape Ecosystem

The grounds of your school make up an ecosystem with complex relationships among the plants, animals, water, soil, sunlight, weather, and other components. Because of these complex relationships, there are many things you will need to pay attention to when promoting plant health. Questions you will need to answer include:

- What is your climate? What are the maximum and minimum temperatures?
- Are there microclimates in the school yard that might affect plant growth?
- Where do the prevailing winds come from? Are they unusually strong?
- What are your seasonal patterns of precipitation?
- Where are the sunny and shady parts of the yard? (These will change over time as plants grow and die.)
- What are the characteristics of the soil in each part of the yard?
- What are the drainage patterns?
- What is the history of each area in the school yard? What plants were grown there? (This can be an important factor for some plant diseases that persist in the soil or mulch.) Was the area covered with asphalt or concrete at some point? Did a road or path go through the site?
- Are animals such as squirrels, deer, and dogs having an impact on the landscape? (The salts in dog urine can be very damaging to plants.)
- What human activities are having an impact on the landscape? Are children vandalizing plants? Are lawns growing right up to the trunks of trees so that mowers regularly damage the trees? Are city deicing operations salting up the soil?
- What kind of irrigation system is installed in the landscape, and is it in working order? Are plants getting too little or too much water?
- Is air pollution a problem in your area? (Air pollution affects plants as well as animals.)

Since landscapes are constantly changing, you will need to monitor frequently in order to detect problems early. Monitor at least every two weeks during the growing season. In mild climates, you also should monitor once a month during the winter. Focus your monitoring efforts on your key plants and key problems. Be aware that plants growing in poor conditions are under stress and are often more likely to suffer from insects and disease. As you monitor, look for the kinds of damage symptoms you learned about in your research.

Promote Plant Health

Proper plant care is the foundation of a plant heath care management program. Healthy plants mean healthy landscapes, and healthy landscapes have fewer problems and require less special attention. The following points will help you minimize cultural and environmental problems as well as pest problems:

- Match the plant to the site. For example, you cannot grow a subtropical swamp plant in a cold, dry site. Some plants cannot grow in full sun, and some plants are better adapted to salty or compacted soil or soil with poor

drainage. For help with finding plants for your area or problem sites, talk to local gardening clubs, nurseries, and extension personnel, consult books on regional gardening, and check land-grant university websites for lists of site-specific plants.

- Select pest- and disease-resistant species.
- Know what kind of care each plant needs, and pay special attention to how you water, prune, and fertilize them.
- Plant a diversity of species so that a single pest problem will not devastate your landscape.
- Include "insectary" plants in your landscapes. These are plants that attract and feed beneficial insects with their nectar and pollen—for example, sweet alyssum (*Lobularia* spp.), flowering buckwheat (*Eriogonum* spp.), members of the parsley family (Apiaceae), such as fennel and yarrow, and members of the sunflower family (Asteraceae), such as sunflowers, asters, daisies, marigolds, and zinnias.
- Use proper planting techniques when installing vegetation.
- Improve the soil with organic matter and mulches.

Consider a Variety of Strategies to Manage Pests

If you determine that a problem needs to be treated, it is important to consider a variety of strategies and integrate those strategies into a comprehensive program. Treatment strategies can be divided into several general categories.

- **Education.** This can include educating students and teachers about respect for landscape plantings; the more students can be involved in the planting and care of various portions of the school yard, the less likely they will be to vandalize these areas. Education can also involve training maintenance staff in various aspects of plant care and plant selection.
- **Cultural and design/maintenance controls.** These usually include modifying horticultural practices to prevent plant problems or improve plant health. These can also include replacing plants that have the same damaging insect or disease problem year after year with a plant that is better suited to the site.
- **Biological controls.** Biological control uses other organisms to combat pests. Increasingly, beneficial organisms are becoming commercially available, and by planting "insectary" plants (see above) you can attract beneficial insects already in your area.
- **Chemical controls.** Chemicals are not prohibited in a PHC program, but they are used as a last resort, and then they are used judiciously and in the least toxic formulations. Always spot-treat to minimize the amount of active ingredient used. Pesticides must be used in accordance with their EPA-approved label directions, including that it is labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and Safety Data Sheets (SDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label. **Pennsylvania law allows pesticide applications in schools and childcares only by certified applicators, registered technicians, or noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must also be posted on school grounds at the place to be treated at least 72 hours prior to and for 48 hours after the application. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied on school grounds and students are expected to be in the immediate vicinity for normal academic instruction or extracurricular activities.**
- **No action.** This can be a valid strategy in many situations when the problem does not seriously affect the health of the plant. Your research will help you understand which problems are serious and which are minor or simply aesthetic.

IPM for Weeds

INTRODUCTION

A "weed" is commonly defined as a plant growing in a place where it is not wanted. Plants can be unwanted because they compete with desired species, cause harm to people or structures, or their appearance or odor is offensive. The designation "weed" can be quite subjective. For instance, the dandelion can be considered a weed in one setting and a wildflower or culinary herb in another.

On school grounds, there is usually consensus on the weedy nature of certain plant species, such as thistles, docks, crabgrass, and poison ivy, that spring up where they are not wanted. These species have common characteristics that enable them to "take over" when conditions are right. Landscapes can be designed and maintained in ways that minimize conditions suited to weed growth, reducing or eliminating the need for herbicides. The goal is to encourage desirable plants to outcompete weeds in habitats where plant growth is acceptable (shrub beds, turf areas, tree wells, student gardens), and to remove conditions conducive to weeds in areas where vegetation is not wanted (in pavement cracks, on running tracks, under fences). A review of basic principles of weed biology and ecology will help identify conditions that promote weed growth and suggest methods for encouraging competitive desirable vegetation and discouraging weeds. The management of weeds in turf is discussed in the section on school lawns on page 144 of this manual. Extensive information concerning weeds in turf, identification, and control can be found at **extension.psu.edu/weed-management-in-turf**.

IDENTIFICATION AND BIOLOGY

Weeds can be found among both broadleaf plants and grasses. Like all plants, weeds are classified within three general categories according to the duration of their life cycle and their methods of reproduction.

Annuals

Annuals are the most common weeds; they live one year and reproduce by seed. These plants have a rapid life cycle that enables them to germinate, shoot up, blossom, set seed, and die within the space of a few weeks or months. Their rapid life cycle allows them to thrive on a minimum of nutrients and water. Stopping seed production is the key to managing annual weeds.

Biennials

Biennial weeds live two years and reproduce by seed. Typically, the first year they germinate from seed in late summer or fall, form a rosette, overwinter, then bolt, set seed, and die soon afterward. Like annuals, stopping seed production is the key to managing biennial weeds.

Perennials

These weeds live longer than two years. Although perennials produce seeds, the main means of reproduction is usually vegetative—for example, by forming new plants from bulbs or corms or producing new top growth from buds located on underground stems (rhizomes). In general, it is very difficult to obtain effective control of perennials without the use of herbicides, However, using herbicides alone is not the best option either. A combination of IPM tactics that are the most appropriate for the setting will be the best solution to the problem. Keep in mind that since it can take a few years for perennial weeds to overtake an area, it will take some time to get rid of them, too.

WEED HABITATS

Weeds tend to grow in places where the soil is bare or disturbed:

- Areas that have been cultivated (shrub and flower beds)
- Trampled or close-mowed lawns
- Unpaved play areas and paths
- Sports fields
- Fence lines
- Graded roadsides
- Cracks in sidewalks or in other paved areas
- Areas where the same herbicide has been used repeatedly and plants tolerant to that material have moved in

Weedy areas found on school grounds tend to be hot, dry, sunny habitats—often with low nutrient levels and soil moisture. Certain plants, such as dandelions, thistles, knotweeds, plantains, barnyard grass, crabgrass, and goosegrass, take advantage of these conditions. As weeds grow, die, and decompose, the soil is stabilized, erosion is reduced, and the soil environment becomes more

moist and fertile. Under these improved conditions, plant species with less weedy characteristics may eventually displace the weeds; thus, weedy areas may become a meadow, and left undisturbed, may eventually become a forest. However, most school grounds cannot support or commit to this long process or the possible end result, so an IPM approach to managing weeds must be followed.

DETECTION AND MONITORING

The purpose of monitoring is to determine if, when, where, and why weeds are growing or posing a problem, and to follow the priorities based on IPM protocols and tactics. The components of effective weed monitoring are described below.

Mapping Weed Habitats

The first step in monitoring is to map areas where weeds are growing. This does not need to be a detailed, time-consuming process—a rough map will do. For areas to monitor, see the list under "Weed Habitats" above.

Identifying Weed Species

It is important to accurately identify the most common weed species on your school grounds in order to determine appropriate management methods. Knowing the scientific name of the weed makes it much easier to obtain information from research professionals and scientific literature. Assistance is available from county Penn State Extension personnel or pictorial weed guides (e.g., *Weeds of the Northeast* or *Newcomb's Wildflower Guide*). A method for preserving weed samples is described in the box to the right.

Learn about the growing conditions required by the weed as well as its growth characteristics and methods of reproduction. Weeds can be indicators of soil conditions that need to be changed to discourage weed growth. For example, yellow nutsedge (*Cyperus esculentus*) often grows in waterlogged soils, indicating excessive water perhaps due to a broken irrigation pipe or valve. Conversely, prostrate knotweed (*Polygonum aviculare*) indicates dry, compacted soil that requires aeration and addition of organic matter. Changing the conditions indicated by the weed can discourage these unwanted plants from growing.

Recordkeeping

It is important to record the time of year a particular weed species appears, its abundance, and its impact on the landscape. This information will help determine:

- Which weeds and how many of each can be tolerated in a specific area without the weeds impairing the function of the landscape or its aesthetic appeal
- Whether or not management strategies are effective
- Whether weed populations are rising, falling, or staying about the same from year to year
- Whether new species of weeds are becoming a problem (as often happens as a result of weed management efforts)

Without this information, it is impossible to determine the long-term effectiveness of management methods.

ESTABLISHING WEED TOLERANCE LEVELS

School landscape maintenance budgets rarely stretch far enough to suppress all weeds, even if that were desirable. Aesthetic standards should be adjusted to take this into account. Assigning

Collecting and Preserving Plant Specimens for Identification

If you want to have a damaged plant inspected or a weed identified, you have a couple of options for assistance:

1. Collect an adequate sample since a small part of a plant may not include all the signs and symptoms needed to make an accurate diagnosis. For plant identification purposes, include leaves, stems, roots, and flowers or seed-bearing portions. A single leaf or leaflet is not an adequate sample for plant identification purposes, and plant material that has been dead for an extended time is generally useless in determining the identity of the causal agent of a disease. Place green leaves between dry paper towels and enclose them in a plastic bag **without adding moisture**. Carefully shake excess soil from roots. Place roots in a plastic bag with moist (not waterlogged) wood shavings or similar material to prevent drying. Wrap fruits separately in paper and mail without adding moisture. If you are unable to deliver the specimen in person, place the bag in cardboard mailing tubes, boxes, or padded mailing envelopes reinforced with cardboard sheets and send it to your Penn State Extension county office.
2. Or, with a good camera or smartphone, take several photos of the specimen in its natural setting, including a few closeups, and email it to your Penn State Extension county office.

tolerance levels helps prioritize budget allocations, facilitate long-term plans, and provide justification for weed management action (or lack of action).

Identify areas where weeds pose potential health or safety hazards or threaten damage to facilities, and distinguish these locations from those where weeds are considered aesthetic problems alone. For example, poison ivy can cause severe skin rashes and itching, and weeds growing in playing fields or running tracks can pose tripping hazards. Assign low tolerance levels to weeds in such areas, and place high priority on their management. On the other hand, assign higher tolerance levels—and lower priority for management—to weeds growing in shrub beds or along fence lines.

Since most weed tolerance levels are subjective, one way to establish them is to invite a representative group to tour the school grounds and decide where weed levels are acceptable and where they are not. Such a group might include the school principal, coach, landscape maintenance supervisor, PTA officers, students, and parents. It is important that this group reach consensus on overall weed management objectives for various school sites, and that weed tolerance and action levels derive from this agreement. Weed tolerance levels can be reevaluated on an annual basis.

LONG-TERM WEED MANAGEMENT PLANS

Long-term plans should focus on making changes to the habitat to permanently exclude weeds in areas where weed tolerance levels are low. In some cases, this may require augmented budget allocations. Developing plans can help spread budget needs over several years.

EVALUATION OF WEED MANAGEMENT PROGRAMS

The availability of herbicides has often helped perpetuate poor landscape designs and inappropriate maintenance practices because herbicides could be used to compensate for them. Gathering monitoring data can pinpoint the underlying causes of weed presence. The data can be used to change design specifications for landscapes, sport fields, playgrounds, and pavement to avoid encouraging weeds.

The long-term costs, risks, and benefits of various weed management approaches should also be evaluated. A one-time cost to install concrete or asphalt mow strips under backstops and fence lines and thereby permanently remove weed habitat may be less costly in the long run than repeated herbicide use that may pose a potential health risk, possibly resulting in lawsuits and poor public relations.

MANAGEMENT OPTIONS

Horticultural Controls

This approach involves manipulating plant selection, planting techniques, and cultural practices so that desired vegetation grows so densely and vigorously that weeds are crowded out.

Planting beds can be rototilled and irrigated to force weed seeds to germinate. As soon as sprouted weeds appear as "green fuzz" on top of the soil, they can be killed by a second cultivation with the tiller set at 1 inch. Shallow cultivation prevents weed seeds from being moved to the top 2 inches of soil (the germination range). While this method will take time and money and needs to be factored into a tolerance approach and the overall budget, it will reduce weed growth while ornamental plants are becoming established.

Plant Selection

In shrub beds, you can include groundcovers with rapid, spreading growth habits that can outcompete weeds. Consider the use of cover crops and allelopathic plants with deterrent/repellent properties such as buckwheat or sunflower.

Competitive Interplanting

When shrubs or groundcovers are installed, weeds often colonize the spaces between individual plants before the ornamentals can spread and shade them out. These weed habitats can be eliminated by overseeding newly planted areas with fast-growing annual flowers such as sweet alyssum (*Lobularia maritima*), farewell-to-spring (*Clarkia amoena*), and scarlet flax (*Linum grandiflorum* var. *rubrum*).

Mulching

Mulches are used primarily to exclude light from the soil, thus limiting weed seed germination. Mulches can be composed of organic materials (compost, wood chips), stones or gravel, or synthetic landscape fabric. Landscape fabric is preferred over black plastic because it allows air and water to move through the soil to benefit ornamental plant roots but excludes light at the soil surface to thwart weeds.

To be effective, mulches should be applied immediately after plants are installed. Bark or compost mulches should be 3–4 inches deep to exclude light. If landscape fabric is used, it should

be covered with an inch or two of bark, stones, etc., to improve the aesthetic appearance of the planting area and reduce degradation of the fabric by sunlight. Landscape fabric can last for years if properly maintained. Mulch should not touch buildings—it often contains mold and insects, including wood-destroying organisms. You do not want to make their entrance into buildings easy. Maintain a 6- to 18-inch-wide strip around buildings that is free of mulch and vegetation. "Pea gravel" (small, round gravel) is often specified for these areas, but recent research has shown that sharp stones 2 inches in diameter in an 18- to 24-inch-wide belt are more effective at deterring rats.

Physical/Mechanical Controls

Hand pulling, cultivation, and using string trimmers and mowers are very effective weed suppression techniques. If labor is in short supply, make good use of parent and student volunteers, community service groups, and youth groups. Classrooms can adopt a flower bed or a section of the school yard to maintain and beautify. If students are involved in grounds maintenance, they will be more careful around the plants and take pride in a clean, well-maintained school yard.

Weeds on baseball infields, running tracks, and other bare soil areas can be suppressed by periodic shallow cultivation with a tractor-mounted rotary harrow, also called a rotary hoe or power rake. In areas with heavy clay soils, this method can be combined with adding sawdust to reduce the crusting and puddling characteristics of these soils.

Eliminate Weed Habitat

Creating a "mow strip" under and immediately adjacent to fence lines can solve a common weed problem. When fencing to surround paved playing surfaces such as basketball courts, the steel fence posts can be installed directly into the paving material, 8–12 inches to the inside of the paving edge. The paving prevents weeds from growing under or adjacent to the fence and provides a paved strip for the wheel of a mower, which can keep adjacent grass trimmed. The strip also provides access for use of string trimmers when shrub beds abut the fence line. Use asphalt or cement crack filler to fill in cracks in paved areas where weeds are a problem.

Flaming

Flamers are used by a growing number of parks and school districts to treat weeds in pavement cracks, under picnic tables and benches, along fence lines, and in similar places. This technique uses a small gas- or propane-fired torch to sear the tops of young weeds. The heat raises the temperature of the sap in the plant cells, the cell walls rupture, and the weed wilts and dies. Flaming is most effective on young annual and perennial weeds in the seedling (four- to five-leaf) stage because at that point the fragile root system is killed along with the top growth. Grasses are difficult to kill by flaming because a protective sheath covers their growing tips. Established perennials are also difficult to control using this method only because they simply regrow from their extensive root system.

Keep the torch about 6 inches above the vegetation and pass it slowly over the plants. Hold the flamer over each plant briefly so the plant is heated but not actually burned. The leaves may lose their usual green color, but there may not be any evidence of wilting, let alone plant death, for several to many hours. Leaves that have been heated sufficiently to burst cell walls will feel very soft to the touch and may turn a purplish color.

Soil Solarization

This technique uses a covering of clear plastic to raise soil temperatures high enough to destroy weeds and their seeds. For solarization to be effective, daytime temperatures should average 85°F or higher, so it should be done during the hottest and sunniest time of the year. Solarization can kill annual or perennial weeds as well as soil pathogens and nematodes. Solarization can also be used to destroy weed seeds and other soil pests in rototilled beds scheduled for new plantings. To solarize a section of soil:

- Mow any existing vegetation to the ground.
- Cultivate to incorporate the vegetation into the soil.
- Provide a smooth surface by raking the soil so it is level.
- Encourage weed seeds to germinate by irrigating the soil one to two weeks before covering it.
- Irrigate again just before laying down the plastic.
- Use UV-stabilized plastic 2 to 4 mils thick.
- Anchor the tarp by burying its edges in a small soil trench around the area to be solarized.

Chemical Controls

When nonchemical weed management methods are not sufficient to solve weed problems,

herbicides (pesticides designed to kill plants/weeds) are available for integration into the program. There are many herbicides on the market. For information on the efficacy and hazards of various herbicides and how to select an appropriate application method for your situation, consult the Penn State Extension office in your county.

Whenever possible, apply herbicides as spot treatments to the target weeds. For example, a tool called a rope wick or sponge applicator can be used to wipe a small amount of herbicide on a single plant or patch of weeds. This reduces human exposure and helps protect nontarget vegetation and beneficial soil organisms that can be damaged or killed by herbicide residues. Wick applicators are available as handheld versions or attachments to small tractors and riding mowers. When applying herbicides, use a colorant to mark the treated area. This will not only ensure even coverage but will also help passersby see and avoid the treated area. Do not allow children to play or lie on the treated area; rope it off and post a sign until the reentry interval (REI), found on the herbicide label, has passed.

Pesticides must be used in accordance with their EPA-approved label directions, including that it is labeled for the intended site. Applicators should always wear protective equipment during applications. All labels and Safety Data Sheets (SDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless specified by the product label. **Pennsylvania law allows pesticide applications in schools and childcares only by certified applicators, registered technicians, or noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must also be posted on school grounds at the place to be treated at least 72 hours prior to and for 48 hours after the application. The law also mandates a seven-hour reentry period (or longer if required by the pesticide label) if a pesticide is applied on school grounds and students are expected to be in the immediate vicinity for normal academic instruction or extracurricular activities.**

Frequently Asked Questions:
IPM Plans and Pesticide Notification Legislation, Acts 2002-35 and 2002-36 of Pennsylvania

Since the publication of this manual, the Pennsylvania IPM Program has received many questions about the proper application of IPM procedures and interpretation of state pesticide laws. Since many school officials often have the same questions, the answers to these questions have been compiled here.

Specifically, the "Frequently Asked Questions" section addresses Acts 2002-35 (Integrated Pest Management Plan Act) and 2002-36 (Pesticide Notification Act) as well as IPM implementation. The legislation requires schools to adopt an IPM plan and provide notification to parents, students, and teachers in advance of pesticide applications.

Disclaimer: The answers to these questions are for guidance and information. If you need further clarification, contact your school solicitor or the Pennsylvania Department of Agriculture at 717-772-5212 for pesticide information and 717-772-5204 for IPM plan information.

The following is a catalog of questions and answers to date grouped together by subject. See **extension.psu.edu/ipm** for additional questions.

Administration Buildings

Q. *Do the regulations apply to public school administration buildings?*

A. Yes, the workers in the building must be notified 72 hours prior to any pesticide applications, and posting must be done 72 hours prior to and 48 hours after applications. Parents and guardians only need to be notified of applications in buildings in which their students attend.

Athletic Fields

Q. *Our athletic fields are not fenced in. Where do the pest control signs need to be posted?*

A. PDA recommends posting the signs at common entry points as determined by the school IPM coordinator. A notice of placement of signs could be posted on the staff bulletin board and sent to parents and guardians so they know where to look for the pest control signs.

Q. *One of our athletic fields is several miles away from any of our school buildings. Does a notice need to be placed in each school building prior to pesticide applications on that field?*

A. No, only workers in buildings at that location need notification. Whatever method your district uses for notification (postings in the buildings, emails, announcements) needs to be followed. The legislation also requires that a pest control sign be placed at the common entry point to that field. The seven-hour reentry time applies.

Q. *We only treat the athletic fields in the summer. Is it necessary to notify the parents and guardians at that time?*

A. No, unless students are using the fields for normal academic instruction or organized extracurricular activities. However, workers in the schools at the locations need to be notified and the fields must have the treatment signs posted at common entry points. The seven-hour reentry time also applies.

Background Checks for Pest Management Professionals

Q. *What are the requirements for background checks on pest management professionals servicing a public school in Pennsylvania?*

A. The IPM legislation does not address this, but the district may require a criminal background check (Act 34 clearance), a child abuse

background check (Act 151 clearance), and, if from out of state, an FBI fingerprint card.

Baits and Gels

Q. *Baits and gels are pesticides. Do parents and guardians need to be notified if either is used?*

A. No, baits and gels are exempt from the notification. However, the certified pesticide applicator is required to notify any individuals on the PDA Hypersensitivity Registry, and if the bait or gels are placed in a common access area, existing regulations require that no students be in the area for seven hours.

Biocides

Q. *We use biocides in the air-conditioning units on our buildings. Do the notification and posting requirements apply to their use?*

A. Biocides used as antimicrobials in areas (air filtration systems, etc.) to which students do not have access are exempt from notification.

Category 18 Certification

Q. *Our vo-ag teacher is certified in Category 18 (Research and Education). Can she do our pesticide applications on the football field and in the buildings?*

A. No, Category 18 is only for research and education. Applying pesticides in schools and on school grounds requires Category 23 (Parks and Schools) or other specific categories (structural, etc.).

Common Access Area

Q. *What is meant by "common access area"?*

A. An "area of common access" in Act 36 refers to where a pest control sign must be posted, such as the main entrance, lobby, or main bulletin board area. "Common access area" is not a term used in Act 36, but it is defined in the Title 7 Chapter 128. 2 as "the areas within a school building where students/attendees normally congregate, assemble or frequent during normal academic instruction or extracurricular activities. The term does not include areas such as kitchens, boiler rooms, utility/maintenance rooms, and areas that are physically blocked or restricted from student/attendee access."

Containerized Bait Placement

Q. *What regulations affect containerized bait placement?*

A. Containerized baits are exempt from the notification and posting requirements but not from the Pesticide Control Act of 1973; they cannot be placed in a common access area within seven hours of when students may be in that area.

Emergency Applications

Q. *If a wasp nest is found under a sliding board on the school's playground, and a certified pesticide applicator sprays it with a pesticide such as Raid, is notification and posting necessary and when can the area be used again?*

A. This is considered an emergency situation according to Act 2002-36 (see **www.legis.state.pa.us/cfdocs/legis/li/uconsCheck.cfm?yr=2002&sessInd=0&act=36)**. After the pesticide is applied, the school shall notify by telephone any parent or guardian who has requested such notification, close that area of the playground for at least seven hours, and post a pest control sign at the site for 48 hours.

Q. *If a contractor is working on a rooftop ventilating unit and sprays a wasp nest when he opens the unit, do the notification and posting requirements apply?*

A. This is also considered an emergency pesticide application according to Act 2002-36. After the application, those parents and guardians requesting notification must be notified by phone, and the area posted for 48 hours. If this unit were an air intake to the vent system, all common access areas affected by the unit would need to be evacuated for seven hours. **Note:** If the contractor is not a certified applicator or in the presence of a certified applicator, they are in violation of the Pesticide Control Act of 1973.

Exempt Schools

Q. *What schools are exempt from the IPM legislation?*

A. The legislation specifically defines school as "a school district, an intermediate unit, an area vocational-technical school, or any of these entities acting jointly." All other schools are exempt from the legislation.

General School Audit

Q. *Will the state check the IPM plan as part of a normal audit?*

A. School audits done by the Bureau of School Audits in the Department of Auditor General concentrate on areas that generate income, so it is unlikely that the IPM plan will be included in any state audits.

Home Remedies for Pests

Q. *If soapy water or WD-40 is used to spray wasp nests, is notification and posting required?*

A. These are not pesticides and are not covered by the legislation. However, many home remedies may contain materials that are actually more toxic than commercially prepared pesticides that have been tested for their safety and effectiveness. The department suggests checking with the school solicitor concerning liability before using any home remedies for pests.

Hypersensitivity Registry

Q. *What is the Hypersensitivity Registry and how can I get a copy for my district?*

A. This is a listing, mandated by the Pesticide Control Act of 1973 and maintained by PDA, of people who have had their hypersensitivity to pesticides verified by a physician and have asked to be included in the registry. People in the registry must be notified by the certified applicator of any pesticide applications within 500 feet of their primary residence or secondary location. Copies of the registry are provided to each licensed commercial and public pesticide application business. The application is available at **www.pahouse.com/files/2017-02-07_020919__Pesticide%20Hypersensitivity%20application.pdf**.

Q. *If we follow all the guidelines of the Hypersensitivity Registry and our school's notification list, can the people notified prevent the school from using the pesticides?*

A. No, parents and guardians can keep the student at home at the time of application, but they cannot stop you from using the pesticide.

Improper Use of Pesticides

Q. *If a teacher uses a can of Raid to eliminate some ants in the corner of his/her classroom, do the notification and posting requirements apply?*

A. First, the teacher would be in violation of the Pesticide Control Act of 1973 since only certified applicators may apply pesticides. Second, the room and any adjoining rooms sharing a common ventilation system must be evacuated and closed off for seven hours. Third, because a pesticide was applied in a school by someone other than a certified pesticide applicator, the district could be penalized anywhere from a warning letter to a fine of up to $10,000 depending on the situation. Finally, the room must now have a pest control sign posted for the next 48 hours and the school must notify by phone all persons that requested such notification.

Insect Repellents

Q. *Our teachers take OFF (insect repellent) on field trips to spray on students to repel insects and ticks. Is OFF considered a pesticide?*

A. OFF makes pesticide claims on its label, so it is a pesticide by definition. To apply pesticides, an applicator's certificate is required. However, since OFF is generally available to the public, the department suggests requiring parental permission before using OFF and then letting the students apply a small amount to their hands and rub it on themselves, rather than the teacher doing it for them.

Intermediate Units

Q. *Does an IU office facility without school students housed within our buildings come under the authority of Acts 35 and 36?*

A. Yes, the legislation specifically includes Intermediate Units in the definition of school, so the IU needs to prepare an IPM plan and, in the event of pesticide applications, is required to notify workers in the building and post notices 72 hours prior to applications.

Q. *What is required where an IU has Headstart, Early Intervention, etc., has classrooms at buildings that are not on school grounds?*

A. IUs are included in the legislation; therefore; notification of pesticide applications is

required for all parents and guardians requesting it for the students under the IU programs, as well as posting 72 hours prior to and 48 hours after pesticide applications. An IPM plan is also needed for the location of the IU programs. The department suggests including the required IPM plan as part of the contract when the site is acquired.

Q. *Who is responsible for IPM at educational trailers owned by an IU and housed at a nonpublic school facility?*

A. The department suggests that an IPM plan be included in the contract when the site is acquired. The IU is responsible for ensuring the students at the off-site facility are covered by an IPM plan and that notification and posting is done according to the regulations.

IPM Plan

Q. *Does our IPM plan need to be approved by the Pennsylvania Department of Agriculture?*

A. No, but PDA is willing to review it and offer suggestions at the school district's request.

Q. *Where can I get more information about developing an IPM plan?*

A. A sample IPM plan is available in this manual (see pages 17–18), which is available for purchase at **extension.psu.edu**.

Q. *Where can I obtain a copy of the sample PSBA IPM Policy?*

A. A copy is found in this manual (see pages 13–14). A copy is also provided in the PSBA policy manual available in all member school districts.

Land Adjacent to School

Q. *Our school district owns land adjacent to the school grounds that is leased to a farmer. Do the notification and posting requirements apply if the farmer uses pesticides?*

A. No, for the purposes of the act the land will be not considered school grounds since it is not under the direct control of the district and is not covered under Act 36.

Q. *Do the notification and posting requirements apply if a neighbor to district property uses pesticides?*

A. No, the act only addresses applications made on school property.

Mosquito Treatments on School Grounds

Q. *Is notification and posting required for a Bt product used for mosquito treatment at a septic system on school grounds that is inaccessible to students?*

A. Notification is not required for the parents or guardians of the students, but workers must be notified and the area posted in accordance with the regulations.

Noncompliance

Q. *What happens if our school district refuses to comply with the new legislation?*

A. Noncompliance of the school code (P.L.30, No. 14) is handled by the School Services Unit of the Pennsylvania Department of Education, which will process the refusal to comply in their usual manner. If the noncompliance involves using a noncertified applicator to apply pesticides, the school would be in violation of the Pesticide Control Act of 1973 and the Pennsylvania Department of Agriculture will investigate. This could lead to penalties anywhere from a warning letter to a fine of up to $10,000 depending on the situation. If a student is harmed by an illegal application of a pesticide, the parent or guardian may also have grounds for a lawsuit.

Nondistrict-Sponsored Activities

Q. *Our buildings/athletic fields are used evenings and weekends for nondistrict-sponsored events. Some participants are district students. How do the regulations relate to this?*

A. Acts 35 and 36 (and Section 128.106 in the pesticide regulations) deal only with district-sponsored curricular and extracurricular activities. Nondistrict-sponsored activities are given no additional protections or notifications beyond those on the pesticide label. That participants are staff or students of the school has no bearing. The key issue is if the district has sponsorship or control of the activity. Example: A scheduled preseason summer practice of the high school football team would require notification and the seven-hour minimum reentry time as a district-sponsored activity. A community athletic association game/practice on the same field on the same day with some of the same participants would not require notification, even though the

district approved the use of the facilities. These community group activities are not district sponsored; therefore, they are not covered by these acts or regulations regarding notification or extended reentry times.

Nonpublic Schools

Q. *Do private schools (or colleges, universities, etc.) need to notify parents and guardians about pesticide applications and establish an IPM plan?*

A. No, they are not included in the legislation. However, they are encouraged to develop IPM plans. A school as defined in the legislation is "a school district, an intermediate unit, an area vocational-technical school, or any of these entities acting jointly." In 2012, the Department of Agriculture determined that since daycare providers were covered in the Pesticide Control Act of 1973, they were in fact included under the provisions of the Acts 35 and 36. This manual has been revised to reflect this determination.

Parental Notification

Q. *Does every parent and guardian need a 72-hour notification for every pesticide application in the school or on school grounds?*

A. The PDA suggests generating a list of parents and guardians at the beginning of each school year requesting such notification of individual applications. A sample copy of a letter explaining how parents and guardians can be placed on the list is available in this manual (see page 25). These notifications may be made by first-class mail, email, or other suitable means.

Q. *In what form may workers and parents and guardians be notified?*

A. Notification to workers in the building must be made 72 hours in advance of pesticide applications through bulletin board notices, emails, individual notices via interoffice mail, or in-house TV announcements. Parents and guardians may be notified through faxes, email, mail, or notices sent home with students.

Q. *If pesticides need to be used where students do not have access, such as the furnace room, do the notification and posting requirements apply?*

A. Parents and guardians do not need notification, but employees in the building need notification and the area needs to be posted.

Q. *Can we send a list of dates of scheduled applications to all parents, guardians, and employees at the beginning of the year to meet the notification requirements?*

A. No!

Q. *Our vocational agriculture program includes training in the use of pesticides as part of the curriculum. If the students apply pesticides in the school greenhouse as part of the curriculum, do the notification and posting requirements apply?*

A. The Pesticide Control Act of 1973 states that "a pesticide other than a disinfectant or sanitizer may not be applied in a common access area within a school building when students are expected to be in the common access area for normal academic instruction or organized extracurricular activities within 7 hours following the application." Therefore, students may not legally apply pesticides, even as part of the curriculum.

Q. *Does the legislation require notification and posting for swimming pool chemicals?*

A. No, the legislation exempts these from notification and posting.

Out-of-State Applicators

Q. *Our school district is near the state line. Can we contract with an out-of-state pest management professional for pest control in our schools?*

A. Yes, provided the pest management professional is certified in the appropriate categories and has registered with the PDA by remitting the required fees to be certified in Pennsylvania. The pest management professional is not required to be retested; they only need to send the required amount for certification because of reciprocal agreements with each of our surrounding states.

Outside Agencies Using Pesticides

Q. *If a utility company, department of transportation, or the county uses pesticides around meters or rights-of-way on the school property, does notification and posting apply?*

A. Since the application is on school property, the notification and posting requirements would apply. The applicator (utility company,

department of transportation, county) should provide the pest control information sheet and pest control signs to the district. Then the district would do the notification and posting in its usual way.

Pest Control Information Sheet

Q. *Where can I get a sample copy of a pest control information sheet?*

A. See page 27 of this manual. You may also contact Cathy Thomas at 717-772-5204 or caththomas@pa.gov for a copy of the sheet.

Pest Control Sign

Q. *Where can I get a sample copy of a pest control sign?*

A. See page 28 of this manual. You may also contact Cathy Thomas at 717-772-5204 or caththomas@pa.gov for a copy of the sheet.

Pesticide Applicators

Q. *Who can apply pesticides in schools or around school grounds?*

A. Only a certified applicator, a registered technician, or a person under the control of the certified applicator who is physically present at the time may apply pesticides.

Q. *Who is a "certified applicator"?*

A. A certified applicator is a person who has been found competent to apply pesticides in the Commonwealth by passing pesticide certification exams administered by the PDA.

Q. *Our school wants a staff member certified to make the pesticide applications. How much does it cost?*

A. Applicator exam fees are $50 for the core and $10 for each category. A three-year certificate is $10, and the school will also need to register with PDA for a pesticide business license ($35 per year). In addition, the school must meet the requirements for comprehensive general liability insurance coverage for pesticide applications. For further information, go to **www.paplants.pa.gov**.

Q. *Which category is appropriate for an applicator to be certified in to apply pesticides on district property?*

A. Category 23 (Park/School Pest Control) will cover all application on district property with the exception of swimming pools. Category 24 (Swimming Pools) is needed for persons applying swimming pool chemicals.

Q. *Does an applicator certified in a category such as 7, 12, 15, or 16 also need Category 23 to apply pesticides in schools?*

A. No, Category 23 is a category designed to cover all areas needed in pest management in schools, except the swimming pool. An applicator with Category 7 can apply lawn and turf pesticides but cannot apply pesticides in an area in which they are not certified, such as spraying for cockroaches in a building.

Q. *What is a registered technician?*

A. A registered technician is a person who is trained to do certain pesticide applications, meets the competency requirements of the Pesticide Control Act of 1973, and acts under the supervision of a certified applicator who is responsible for the applications and is available when needed. The training is provided by the certified applicator with at least one year of experience as required by the Pesticide Control Act. A registered technician's certificate is $20 per year.

Pesticide Treatments While School Is in Session

Q. *Which areas in a school could possibly be treated with a pesticide while school is in session?*

A. Except as provided in the second sentence, pesticides may not be applied within a school building or on school grounds where students are expected to be present for normal academic instruction or organized extracurricular activities within seven hours (or reentry time restrictions contained on the pesticide label, whichever time period is longer) following the application. Students may not be present in an untreated portion of the school building unless the area being treated has a separate ventilation system and is separated from the untreated portion by smoke or fire doors or is a separate building.

Pesticides

Q. *What is considered a pesticide?*

A. A pesticide is a substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest, and any substances or mixture of substances intended for use as a plant regulator, defoliant, or desiccant. Included are herbicides, fungicides, rodenti-

cides, insecticides, and antimicrobials. Pesticides such as Raid and poison-free pesticides are also included in this legislation.

Poison-Free Pesticides

Q. *Can our district use the poison-free pesticides now being marketed for school use without notification and posting?*

A. Poison-free pesticides are considered pesticides by PDA and thus fall under the notification and posting requirements just the same as any other pesticide.

Recordkeeping

Q. *The legislation states that the three-year record-keeping requirement does not apply to swimming pool maintenance chemicals or baits and gels. Does that mean I no longer need to keep those records?*

A. The Pesticide Control Act of 1973 still requires records be kept by the applicator for swimming pool maintenance chemicals and baits and gels for the three-year period. The act does not change this.

Contract Guide Specifications or Request for Proposal

Q. *Where can I get a sample copy of a request for proposal or contract guide specifications to provide potential pest management professionals for bidding purposes?*

A. There is a sample in this manual on pages 19–23.

Students

Q. *Does the term "student" include adult night school students for the purpose of notification?*

A. Act 2002-36 specifies that notification must be given to workers in the school building and parents and guardians of enrolled students. Many adult classes meet only once or twice a week. PDA suggests that the district give the adult students in those night classes the opportunity for notification by informing the district, in writing, of their desire to be placed on the district's notification registry, but the legislation is silent on this.

Visiting Schools

Q. *Is notification required for a visiting school coming to a sporting event or other activity?*

A. Notification is required for workers in the building and parents and guardians requesting it for their students who attend the school. Posting signs serve as notice for any other visitors to the school. The seven-hour reentry time for the area is still in effect.

References and Resources

References by Section

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WEBSITES, VIDEOS, AND OTHER MEDIA

Looking for more information and additional resources? Search for "School IPM" on YouTube, the U.S. EPA website, or university websites. Remember, while doing an online search, be sure you are using reputable sources such as those from Cooperative Extension, universities, peer-reviewed journals, and other evidence-based and well-researched sites. For more information from the PA IPM Program, go to **extension.psu.edu/ipm**.

Appendix A:
Pesticide Rules and Regulations in Pennsylvania Schools and Childcares

Laws and regulations impacting schools and childcares have been passed over the years and involve multiple agencies' jurisdictions. Consequently, there can be confusion about and inconsistencies in the details of legal requirements. This is also true of pesticide legislation and regulation in schools.

Until recently, schools were treated as merely another type of environment in which pesticides were regulated under the Pennsylvania Pesticide Control Act of 1973. No regulations were in place to account for the special sensitivity of school environments. The longstanding regulation provided for the training and licensing of pesticide applicators in school environments and placed limitations on who was allowed to apply pesticides. A hypersensitivity registry was enacted to allow for special prenotification of sensitive individuals statewide in the event of a pesticide application in their home or workplace. These regulations were promulgated and enforced by the Pennsylvania Department of Agriculture.

In 2002, legislation was enacted requiring each Pennsylvania school district, intermediate unit, and area vocational-technical school to develop an integrated pest management (IPM) plan (Act 35 of 2002) and to notify parents and guardians 72 hours prior to any pesticide applications and post warning signs 72 hours prior to and 48 hours after any pesticide applications in school buildings or on school grounds (Act 36 of 2002).

In 2012, the Pennsylvania Department of Agriculture's Health and Safety Division determined that these regulations apply to childcares as well as K–12 schools since childcare facilities are explicitly covered by the Pennsylvania Pesticide Control Act of 1973. Note that his includes the provision that **only** a licensed pest control operator can apply a pesticide in a facility or a home-based childcare center.

The following information is excerpted from the publication **PENNSYLVANIA PESTICIDE CONTROL ACT OF 1973, Act of March 1, 1974, P.L. 90, NO. 24, 3 P.S. 111.21-111.61 (1987).** For complete text, refer to the actual publication. Copies are available from the Pennsylvania Department of Agriculture, 2301 North Cameron Street, Harrisburg, PA 17110-9408.

In order to apply pesticides in a school or on school grounds, the applicator needs to be a **certified public/commercial applicator** (section 17.1), a registered **pesticide application technician**, or a noncertified applicator or nonregistered technician **under the direct supervision of a certified applicator** (Sections 16.1 and 16.2).

Pesticide in this document means any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest, and any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant (Section 4 [31]).

For in-house pest control, Section 15.1 (Pesticide Application Licensing) applies: "Each . . . government agency or other entity engaged in applying or contracting for the application of pesticides, as meets the definition of 'commercial applicator,' shall hold a license stating those categories in which it is to do business. No license shall be issued to any . . . agency, nor shall any license remain valid unless such . . . agency has a certified applicator in its employ at all times."

Sections 29 and 30.1 provide for Criminal Penalties and Civil Penalties for violation of the above regulations.

The next section is from the publication **TITLE 7—AGRICULTURE, DEPARTMENT OF AGRICULTURE, PART V. BUREAU OF PLANT INDUSTRY, [7 Pa. Code CH. 128], PESTICIDES, RULES AND REGULATIONS.** (The second part of the reference listed at the end of this article.)

Definitions from § 128.2

Common access area—The areas within a school building where students/attendees normally congregate, assemble or frequent during normal academic instruction or extracurricular activities. The term does not include areas such as kitchens, boiler rooms, utility/maintenance rooms, and areas that are physically blocked or restricted from student/attendee access.

Current registry—The Pesticide Hypersensitivity Registry with the most recent effective date.

Governmental entity—Any executive or independent agency or unit of the Commonwealth, or local agency, including a county, a city, a borough, town, township, school district, municipal authority, or political subdivision thereof.

Integrated pest management—The managed use of combined pest control alternatives, including cultural, mechanical, biological, and chemical, to most effectively prevent or reduce to acceptable levels damage caused by pests.

Pesticide hypersensitivity—Excessive or abnormal sensitivity to pesticides.

School—A public, nonpublic, or licensed private elementary or secondary school wherein a resident of this Commonwealth may fulfill the compulsory school attendance requirements and that meets the applicable requirements of Title IV of the Civil Rights Act of 1964 (42 U.S.C.A. § 2000c) (Public Law 88-352, 78 Stat. 241). The term also includes a kindergarten or preschool program operated by a school and a child daycare center operating under a certificate of compliance issued by the Department of Public Welfare.

§ 128.41. Requirements for Certification

(a) A person is deemed to be a commercial or public applicator and required to be certified if one or more of the following criteria are met:

(3) A person who applies or supervises the application of a pesticide to the following locations or who is involved in the following types of application:

(i) *Fumigation.*

(v) *Playgrounds and athletic field*—Includes a person who applies a pesticide to a public playground or an athletic field.

(vii) *Schools*—Includes a person who uses a pesticide on school property, except for the use of disinfectants and sanitizers within the school building.

§ 128.42. Categories of Commercial and Public Applicators

(11) *Household and health related*—The use of a pesticide in, on, or around a food handling establishment, a human or nonagricultural animal dwelling, an institution such as a school or hospital. . . .

(12) *Wood-destroying pests*—The use of a pesticide to control or prevent termites, powderpost beetles, or other wood-destroying pests infesting a residence, school, hospital, . . . and an area adjacent to those structures.

(23) *Park or school pest control*—The use of a pesticide in a campground or recreational area of a public or private park or on school property. *(This category is recommended for in-house personnel.)*

§ 128.106. Additional Responsibilities within School Buildings

A pesticide other than a disinfectant or sanitizer may not be applied in a common access area within a school building when students are expected to be in the common access area for normal academic instruction or organized extracurricular activities within seven hours following the application. The applicator shall also comply with reentry time restrictions contained on the pesticide label, whichever is greater.

Reference: PENNSYLVANIA PESTICIDE CONTROL ACT OF 1973, Act of March 1, 1974, P.L. 90, No. 24, 3 P.S. 111.21-111.61 (1987) and TITLE 7—AGRICULTURE, DEPARTMENT OF AGRICULTURE, PART V. BUREAU OF PLANT INDUSTRY, [7 Pa. Code CH. 128], PESTICIDES, RULES AND REGULATIONS. (Available from the Pennsylvania Department of Agriculture, Bureau of Plant Industry, 2301 N. Cameron St., Harrisburg, PA 17110-9408.)

Introduction to Acts 35 and 36

Acts 35 and 36 are provided on the following pages. (For a detailed description of these acts, see pages 11–12.) These laws differ from the Pennsylvania Pesticide Control Act of 1973 and Worker Protection Standards in that they were promulgated under the Public School Code of 1949. Although day-to-day enforcement of this law's pesticide components falls to the Pennsylvania Department of Agriculture, the party ultimately responsible for compliance by schools is the Pennsylvania Department of Education.

HOUSE AMENDED

PRIOR PRINTER'S NOS. 761, 1405, 1787 PRINTER'S NO. 1860

THE GENERAL ASSEMBLY OF PENNSYLVANIA

SENATE BILL

No. 705 Session of 2001

ACT 35, signed by the Governor, April 18, 2002

Amending the act of March 10, 1949 (P.L.30, No.14), entitled "An act relating to the public school system, including certain provisions applicable as well to private and parochial schools; amending, revising, consolidating and changing the laws relating thereto," providing for integrated pest management programs in schools.

The General Assembly of the Commonwealth of Pennsylvania hereby enacts as follows:

Section 1. The act of March 10, 1949 (P.L.30, No.14), known as the Public School Code of 1949, is amended by adding a section to read:

Section 772.1 Integrated Pest Management Programs.

(A) Each school shall, by January 1, 2003, adopt an integrated pest management plan in accordance with the integrated pest management policies established by the department on the effective date of this section, until regulations are promulgated by the department.

(B) The department shall do all of the following:

(1) Maintain a Hypersensitivity Registry to assist in the notification of students and employees who are especially sensitive to pesticides.

(2) Designate an integrated pest management coordinator within the department to assist schools in the adoption and administration of integrated pest management plans.

(3) Prepare a standard structural integrated pest management agreement and distribute the standard agreement to schools.

(4) Provide other materials and assistance to schools to aid them in developing integrated pest management plans.

(5) Promulgate regulations, consistent with its policies in effect on the date of this section, to assist schools in implementing their responsibilities under this section.

(C) The following words and phrases when used in this section shall have the meanings given to them in this subsection unless the context clearly indicates otherwise:

"Department." The Department of Agriculture of the Commonwealth.

"Integrated pest management plan." A plan which establishes a sustainable approach to managing pests by combining biological, cultural, physical and chemical tools in a way which minimizes economic, health and environmental risks.

"Pest." An insect, rodent, nematode, fungus, weed or other form of terrestrial or aquatic plant or animal life or virus, bacteria or other micro-organism, except viruses, bacteria or other micro-organisms on or in living man or other living animals, declared to be a pest under section 25(c)(1) of the Federal Insecticide, Fungicide, and Rodenticide Act (61 Stat. 163, 7 U.S.C. § 136w).

"Pesticide." A substance or mixture of substances intended for preventing, destroying, repelling or mitigating a pest and a substance or mixture of substances intended for use as a plant regulator, defoliant or desiccant.

"School." A school district, an intermediate unit, an area vocational-technical school or any of these entities acting jointly.

Section 2. This act shall take effect in 60 days.

PRIOR PRINTER'S NOS. 1506, 2228, 2292, 3461, 3616

PRINTER'S NO. 3678

THE GENERAL ASSEMBLY OF PENNSYLVANIAHOUSE BILL

No. 1289 Session of 2001

ACT 36, signed by the Governor, April 18, 2002

Amending the act of March 10, 1949 (P.L.30, No.14), entitled "An act relating to the public school system, including certain provisions applicable as well to private and parochial schools; amending, revising, consolidating and changing the laws relating thereto," providing for approval of unfounded debt in certain distressed school districts, for educational assessment centers and for notification of pesticide treatments at schools. *(This document only includes the notification of pesticide treatments at schools.)*

The General Assembly of the Commonwealth of Pennsylvania hereby enacts as follows:

Section 1. The act of March 10, 1949 (P.L.30, No.14), known as the Public School Code of 1949, is amended by adding sections to read: *(Sections 636.1 and 697 are omitted in this document.)*

Section 772.1. Notification of Pesticide Treatments at Schools.

(a) The following apply to pesticide applicators:

(1) For a pesticide treatment at a school building, the certified applicator or pesticide application technician shall supply the pest control information sheet and a pest control sign, which must be at least eight and one-half by eleven (8½ by 11) inches in size, to the chief administrator or building manager.

(2) For a pesticide treatment on school grounds, including athletic fields and playgrounds, the certified applicator or pesticide application technician shall supply the pest control information sheet and a pest control sign, which must be at least eight and one-half by eleven (8½ by 11) inches in size, to the chief administrator or grounds manager.

(b) Responsibilities of schools are as follows:

(1) Except as provided in clause (3), notification of pesticide treatments shall be as follows:

(i) For a pesticide treatment at a school building, the school shall be responsible for all of the following:

(A) Posting the pest control sign received under subsection (a)(1) in an area of common access where individuals are likely to view the sign on a regular basis at least seventy-two (72) hours before and for at least two (2) days following each planned treatment.

(B) Providing the pest control information sheet received under subsection (a)(1) to every individual working in the school building at least seventy-two (72) hours before each planned treatment.

(C) Providing notice, including the name, address and telephone number of the applicator providing the treatment, day of treatment and pesticide to be utilized, to the parents or guardians of students enrolled in the school at least seventy-two (72) hours before each planned treatment as follows:

(I) notice to all parents or guardians utilizing normal school communications procedures; or

(II) notice to a list of interested parents or guardians who, at the beginning of each school year, or upon the child's enrollment, requested notification of individual application of pesticides. The school shall provide procedures or materials for such requests to parents and guardians of students. Notification of each pesticide application shall be provided using first class mail or other means deemed appropriate by the school to each parent or guardian requesting notification.

(ii) For a pesticide treatment on school grounds, the school shall be responsible for all of the following:

(A) Posting the pest control sign received under subsection (a)(2) at the place to be treated at least seventy-two (72) hours before and for two (2) days after the planned treatment.

(B) Providing the pest control information sheet received under subsection (a)(2) to every individual working in the school building at least seventy-two (72) hours before each planned treatment.

(C) Providing notice, including the name, address and telephone number of the applicator providing the treatment, day of treatment and pesticide to be utilized, to the parents or guardians of students enrolled in the school at least seventy-two (72) hours before each planned treatment as follows:

(I) notice to all parents or guardians utilizing normal school communications procedures; or

(II) notice to a list of interested parents or guardians who, at the beginning of each school year, or upon the child's enrollment, requested notification of individual application of pesticides. The school shall provide procedures or materials for such requests to parents and guardians of students. Notification of each pesticide application shall be provided using first class mail or other means deemed appropriate by the school to each parent or guardian requesting notification.

(iii) Notwithstanding any other provision of this section, where pests pose an immediate threat to the health and safety of students or employees, the school may authorize an emergency pesticide application. In the case of an emergency pesticide application, the school shall notify by telephone any parent or guardian who has requested such notification. School officials shall annually advise parents or guardians of their right to request notification of emergency pesticide use and shall explain procedures for requesting such notification.

(2) Except as provided in clause (3), each school shall maintain detailed records of all chemical pest control treatments for a period of at least three (3) years.

(3) The notice and recordkeeping requirements in clauses (1) and (2) and subsection (c) do not apply to the application of:

(i) disinfectant and antimicrobial products;

(ii) self-containerized baits placed in areas not accessible to students and gel type baits placed in cracks, crevices or voids; or

(iii) swimming pool maintenance chemicals in the care and maintenance of a swimming pool.

(c) The following prohibitions shall apply:

(1) Except as provided in clause (2):

(i) pesticides may not be applied within a school building where students are expected to be present for normal academic instruction or organized extracurricular activities within seven (7) hours following the application, or on school grounds where students will be in the immediate vicinity for normal academic instruction or organized extracurricular activities within seven (7) hours following the application; or

(ii) the applicator shall comply with re-entry time restrictions contained on the pesticide label; whichever time period is longer.

(2) Students may not be present in an untreated portion of the school building unless the area being treated has a separate ventilation system and is separated from the untreated portion by smoke or fire doors, or is a separate building.

(d) The department shall promulgate such rules and regulations as necessary to administer this section.

(e) The following words and phrases when used in this section shall have the meanings given to them in this subsection unless the context clearly indicates otherwise:

"Applicator." A certified applicator, commercial applicator or public applicator.

"Certified applicator." An individual who is certified under section 16.1, 17 or 17.1 of the act of March 1, 1974 (P.L.90, No.24), known as the "Pennsylvania Pesticide Control Act of 1973," as competent to use or supervise the use or application of any pesticide.

"Commercial applicator." A certified applicator, whether or not he is a private applicator with respect to some uses, who uses or supervises the use of any pesticide on the property or premises of another or on easements granted under State law, or any applicator who uses or supervises the use of any restricted-use pesticide on property owned or rented by him or his employer, when not for purposes of producing an

agricultural product. The secretary may by regulation deem certain types of applicators using any pesticide on their own property or that of their employer as commercial applicators.

"Department." The Department of Agriculture of the Commonwealth.

"Insect." Any of the numerous small invertebrate animals generally having a more or less obviously segmented body, for the most part belonging to the class Insecta, comprising six-legged, usually winged forms, as, for example, beetles, bugs, bees and flies, and to other allied classes of arthropods whose members are wingless and usually have more than six (6) legs, as, for example, spiders, mites, ticks, centipedes and wood lice.

"Nematode." An invertebrate animal of the phylum Nemathelminthes and class Nematoda, that is, unsegmented round worms with elongated, fusiform or sac-like bodies covered with cuticle and inhabiting soil, water, plants or plant parts. The term includes nemas and eelworms.

"Person." An individual, partnership, association, corporation or any organized group of persons, whether incorporated or not.

"Pest." An insect, rodent, nematode, fungus, weed or other form of terrestrial or aquatic plant or animal life or virus, bacteria or other micro-organism, except viruses, bacteria or other microorganisms on or in living man or other living animals, declared to be a pest under section 25(c)(1) of the Federal Insecticide, Fungicide, and Rodenticide Act (61 Stat. 163, 7 U.S.C. § 136w).

"Pest control information sheet." A document which contains the date of treatment, the name, address and telephone number of the applicator, the pesticide utilized and any other information that is required by the Secretary of Agriculture.

"Pesticide." A substance or mixture of substances intended for preventing, destroying, repelling or mitigating a pest and a substance or mixture of substances intended for use as a plant regulator, defoliant or desiccant.

"Pesticide application technician." An individual employed by a commercial applicator or governmental agency who, having met the competency requirements as set forth in the act of March 1, 1974 (P.L.90, No.24), known as the "Pennsylvania Pesticide Control Act of 1973," is registered by the Secretary of Agriculture to apply pesticides under the direct supervision of a certified applicator.

"Public applicator." A certified applicator who applies pesticides as an employee of the Commonwealth or its instrumentalities or a local agency.

"School." A school district, an intermediate unit or an area vocational-technical school or any of these entities acting jointly.

Section 2. This act shall take effect as follows:

(1) The addition of sections 636.1 and 697 of the act shall take effect immediately. (These are not included in this document.)

(2) The addition of section 772.1 of the act shall take effect January 1, 2003.

(3) This section shall take effect immediately.

Appendix B:
What Is the Worker Protection Standard?

The Worker Protection Standard (WPS) is a federal law with which all states must comply. In the Commonwealth, these regulations are also enforced by the Pennsylvania Department of Agriculture. Under the WPS, schools must comply to ensure a safe work environment. The WPS is a regulation issued by the U.S. Environmental Protection Agency (EPA) that covers all restricted- and general-use pesticides used in the production of agricultural plants on farms, forests, nurseries, and greenhouses. In schools, the WPS applies to agricultural and horticultural science programs that are producing agricultural plants in either a greenhouse or field setting. Since students are being compensated by receiving a grade for their efforts, they are considered workers under the WPS. **Note:** Some inconsistency now exists between federal WPS as applied to "students as workers" in Pennsylvania schools and Act 36. Under Act 36, students may not be present in school facilities during or within seven hours of a pesticide application.

- Parental notification is required 72 hours prior to pesticide application.
- Reentry time listed on a pesticide label may be less than that required by Act 36, which requires that the longer REI be followed (seven hours).

Pesticide handlers and workers in areas that have been treated with pesticides may be exposed to pesticides by:

- Preparing pesticides for use, such as by mixing a concentrate with water or loading the pesticide into application equipment.
- Applying pesticides, such as in an agricultural field or greenhouse.
- Entering an area where pesticides have been applied to perform allowed tasks, such as picking crops.

The primary purpose of the WPS is to protect not only those who apply pesticides but also employees who work in areas that have been treated with pesticides within 30 days after the expiration of a restricted-entry interval (REI) following a pesticide application. Designated on the pesticide label, the REI is the time period immediately after the pesticide application when, with few exceptions, students or instructors are restricted from an area that has been treated. The WPS rules cover the REI plus a 30-day time period following the REI.

In general, the WPS requires that the following be provided:

- Information about potential exposure to pesticides
- Information about exposure to pesticides
- Protection against exposure to pesticides
- Ways to mitigate exposures to pesticides
- Access to treatment if a pesticide exposure is suspected

Most WPS requirements apply to all agricultural workers or pesticide handlers, but there are some that only apply to certain persons such as those who handle pesticide application equipment or clean pesticide-contaminated personal protective equipment. All persons must still observe the following:

- Use the required personal protective equipment (PPE)
- Prevent pesticide contact (directly or through drift) during application
- Ensure that people who are not correctly trained and equipped are kept out of areas being treated with pesticides
- Maintain REIs
- Maintain no-contact early entry (includes moving equipment, irrigation, and other tasks where the workers will not come in contact with treated areas)

- Allow for short-term agricultural emergency or specially exempted early entry with proper PPE

The WPS has three main areas of focus: help minimize potential for exposure, provide information and protection, and provide mitigation in the event of an exposure. The following is a brief summary of the key points of each of these focus areas. Complete details about the WPS can be found at **extension.psu.edu/worker-protection-standard-wps-information**.

Providing Information

(The following applies only to those who are working in agricultural areas that have been treated with pesticides.)

- Provide safety training for both handlers and workers, such as the agricultural science instructor or anyone else who may be handling pesticides or working in areas that have been treated with pesticides.
- Allow access to labeling information for handlers and early entry workers.
- Allow access to the central information location, which should be kept in a common access area in close proximity to where agricultural crops are being grown.
- Provide an EPA-approved safety poster at a the central information location.

Providing Protection

- Provide handlers and workers, such as the agricultural science instructor or anyone else, with the appropriate PPE.
- Prohibit handlers from applying a pesticide that will expose workers or other persons.
- Exclude workers from areas being treated with pesticides during the REI.
- Exclude workers from areas under an REI as directed by the pesticide label.
- Equip early entry workers with proper safety training and personal protective equipment.
- Notify workers of applications location.
- Protect handlers during handling tasks.

Mitigation

- Provide decontamination supplies—water, soap, single-use towels, and spare overalls.
- Provide emergency transportation to the hospital for employees who have been exposed to pesticides.

To help growers and schools that produce agricultural crops comply with the WPS, the Rural Health Farm Worker Protection Safety Program was created and is located in the Pennsylvania Office of Rural Health at Penn State. This program is funded by the Pennsylvania Department of Agriculture's Bureau of Plant Industry. The program is run in collaboration with the Penn State Pesticide Education Program and offers:

- WPS training to farmers and growers
- Handler and worker WPS training in language appropriate sessions
- Farm WPS evaluations to help the grower be in compliance with the WPS standard
- Working with grower groups to assist them in their concerns
- Working with farm labor groups in addressing their concerns

The Pennsylvania Department of Agriculture (PDA) is responsible for the enforcement of the WPS in the Commonwealth. The EPA has requested that PDA increase the number of WPS compliance inspections to ensure the WPS is being followed. As a result, inspectors completed more than 300 WPS enforcement inspections last year. Schools are included in these inspections if they fall under WPS criteria.

Penn State Extension County Offices: **extension.psu.edu/county-offices**

Pennsylvania Department of Agriculture Regional Offices: **www.agriculture.pa.gov/regional-offices**

Universal Poison Control Number: **1-800-222-1222**

extension.psu.edu/ipm

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