Technical Information for Pennsylvania Schools—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.

A list of many of the insect, spider, and rodent pests sometimes found in and around Pennsylvania schools appears below. 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, bedbugs, ground beetles, and moths attracted to lights. The list also does not include potential pests like pigeons, starlings, sparrows, Canada geese, chipmunks, groundhogs, or deer.

Information about pests not included in this manual can be obtained from Penn State Cooperative Extension agents, pest management professionals, Web sites, or other references found in the literature citations and additional references listed at the end of this manual.

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

Pests Found In and Around Schools

Ants—Hymenoptera (page 32)	
Carpenter ant	*Camponotus* spp.
Larger yellow ant	*Acanthomyops interjectus*
Odorous house ant	*Tapinoma sessile*
Pavement ant	*Tetramorium caespitum*
Pharaoh ant	*Monomorium pharaonis*
Thief ant	*Solenopsis molesta*
Bees, Hornets, and Wasps—Hymenoptera (page 115)	
Bees	*Apis* spp., *Bombus* spp.
Hornets	*Dolichovespula maculata*
Paper wasps	*Polistes* spp.
Solitary wasps	Various species
Yellowjackets	*Vespula* spp.

(continued on next page)

Cockroaches—Blattaria (page 42)	
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**

* Found in greenhouses and mall plantings in Pennsylvania.

Fleas—Siphonaptera (page 53)	
Cat flea	*Ctenocephalides felis*
Human flea	*Pulex irritans*

Flies—Diptera (page 58)	
Blue bottle fly	*Cynomyopsis cadaverina*, *Calliphora* spp.
Cluster fly	*Pollenia rudis*
Fruit fly	*Drosophila* spp.
Green bottle fly	*Phaenicia sericata*
House fly	*Musca domestica*
Mosquitoes	*Aedes* spp., *Anopheles* spp., and *Culex* spp.
Moth fly (drain fly)	*Psychoda* spp.
Phorid fly (drain fly)	*Megaselia scalaris*

Landscape Pests (page 93)	
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
Plant-sucking pests	
Aphids	Homoptera: Aphidae
Lace bugs	Hemiptera: Tingidae
Mealybugs	Homoptera: Pseudococcidae
Scales	Homoptera: Coccidae, Diaspididae
Spider mites	Acarina: Tetranychidae
Thrips	Thysanoptera: Thripidae
Whiteflies	Homoptera: Aleyrodidae

Lawn Pests (page 76)	
Billbugs	*Sphenophorus* spp.
Chiggers	Acari: Trombiculidae
Hairy Chinch bugs	*Blissus leucopterus hirtus*
Snails	Pulmonata: Helicidae
Sod webworms	Crambinae spp.
Spittlebugs	Homoptera: Cercopidae
White grubs	Coleoptera: Scarabaeidae

Lice—Phthiraptera (page 71)	
Body louse	*Pediculus humanus corporis*
Crab louse	*Phthirus pubis*
Head louse	*Pediculus humanus capitis*
Miscellaneous Pests (pages 37 and 84)	
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
Occasional Invaders	
Boxelder bug	*Boisea trivittatis*
Cluster fly	*Pollenia rudis*
Earwigs	Dermaptera
Elm leaf beetle	*Pyrrhalta luteola*
Millipedes	Arthropoda: Diplopoda
Multicolored Asian lady beetle	*Harmonia axyridis*
Sowbugs	Crustacea: Isopoda
Western conifer seed bug	*Leptoglossus occidentalis*
Rodents (page 73)	
Black rat	*Rattus rattus*
House mouse	*Mus musculus*
Norway rat	*Rattus norvegicus*
Spiders (page 86)	
Black widow spider	*Latrodectus mactans*
Brown recluse spider	*Loxosceles* spp.
Jumping spider	*Phidippus audax*
Wolf spider	Lycosidae
Yellow sac spider	*Chiracanthium* spp.
Termites (page 100)	
Eastern subterranean termite	*Reticulitermes flavipes* *R. hageni* *R. virginicus*
Ticks (page 90)	
American Dog Tick	*Dermacentor variablilis*
Blacklegged Tick (formerly called Deer Tick)	*Ixodes scapularis*
Lone Star Tick	*Amblyomma americanum*

IPM for Ants in Schools

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 aim at preventing ants from invading structures. Unfortunately, prevention is not always successful and management actions must be implemented.

Although ants often are regarded as pestiferous, 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 also are 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 the males serve only to mate with the queens.

Ants pass through four stages of development: egg, larva, pupa, and adult. After mating with males, queens lay 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 and become worker ants.

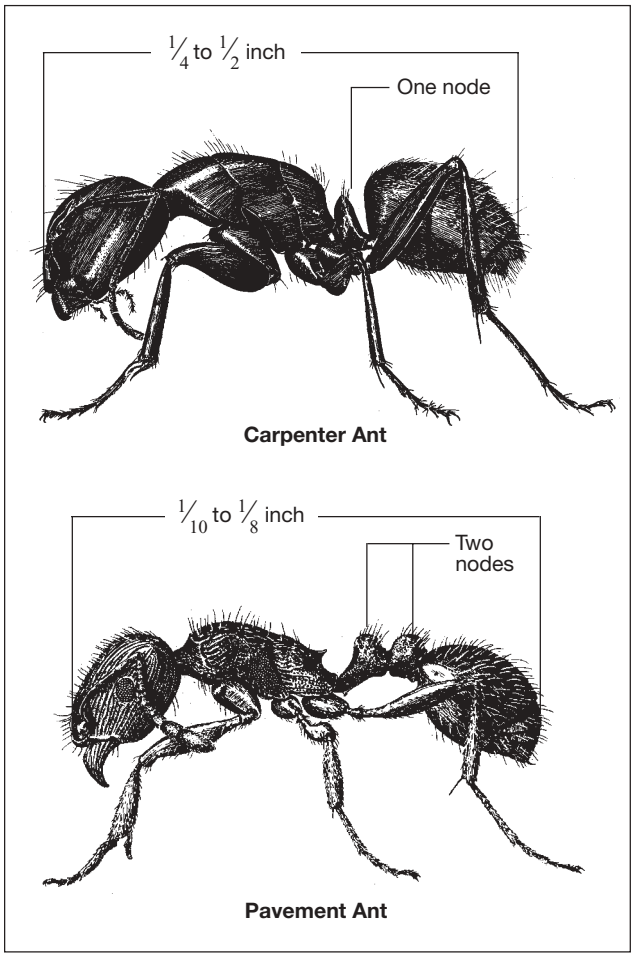
The first step in managing pest ants is proper identification, since many types of ants may invade a structure. It is critical to identify the type of ant you want to management, because most ants differ in their habits and food preferences. See Table 1, "Common House-Invading Ant Species."

DAMAGE

Many species of ants, such as pavement ants, are particularly prone to infesting food. Inside buildings, these ants are merely a nuisance, since they almost never bite. However, ants walk over many different kinds of surfaces and sometimes feed on dead animals and insects, so it is possible that they can carry disease-causing organisms to human food. Assume that ant-infested food has been exposed to organisms that can cause spoilage, and throw it away.

Carpenter ants may cause some structural damage as they excavate moist, rotting wood and other soft materials (such as foam insulation board) to make satellite nests.

FIGURE 1. Carpenter and Pavement Ants



(Illustrations from The Ohio State University fact sheet *Ants in and Around the Home*, HYG 2064-96)

Most of the information for this chapter was modified from:
IPM for Schools: A How-to Manual. United States Environmental Protection Agency. EPA 909-B-97-001. March 1997.
Bode, W. M. and S. B. Jacobs. *Carpenter ants*. The Pennsylvania State University. Entomology-HP-1. 1995.
Jacobs, S. B. *Pavement ant*. The Pennsylvania State University. Entomology-NP-11. 2000.

TABLE 1.

Common House-Invading Ant Species

Species	# of nodes in pedicel	Description of workers	Habits
Pharaoh Ant *Monomorium pharaonis*	2	Small, around 1/16 to 1/12 inch (1.5–2.0 mm) long; yellowish to red; often confused with thief ant, but has 3 segments in the club-like 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*	2	Very small, around 1/16 inch (1.3–1.8 mm) long; yellowish; often confused with Pharaoh ant, but has 2 segments in the club-like 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.
Carpenter Ant *Campontus pensylvanicus*	1	Large, 1/4 to 1/2 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 and foam plastic insulation board to make satellite nests; omnivorous; common house invader.
Larger Yellow Ant *Acanthomyops interjectus*	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.
Pavement Ant *Tetramorium caespitum*	2	Around 1/10 to 1/8 inch (2.5–4 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.
Odorous House Ant *Tapinoma sessile*	1	Around 1/10 to 1/8 inch (2.4–3.25 mm) long; brownish to black; emits foul odor 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.

(Chart adapted for Pennsylvania schools by J. Kenneth Long, Jr., PA IPM program assistant, October 1999, from the University of Florida School IPM Web site article Common House-Invading Ant Species at **schoolipm.ifas.ufl.edu/tp6b.htm**)

DETECTION AND MONITORING

Visual inspection is the most useful monitoring technique for detecting ants, and can be very useful in 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 bright flashlight, kneepads, 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.
- Keep accurate records during the monitoring program to help formulate an IPM plan and evaluate its effectiveness.
- 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 that recyclables have been cleaned before being placed in bins.
- Talk with kitchen staff and custodians to learn more about the problem from their perspective.
- Ants can be attracted to snacks kept in classrooms or teachers' lounges and to sweet drinks accidentally spilled on the floor.
- Glue boards or sticky traps placed in areas ants are likely to be found can be useful in monitoring.
- 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).

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.

Caulking

- Caulk all potential entryways with a silicone caulking compound.
- Use mildew-resistant caulk in moist areas.
- It is not necessary or practical to seal all cracks, but 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.

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.
- Periodically give all food preparation areas a complete cleaning, focusing on areas where grease and food debris accumulate. These include drains, vents, deep fat fryers, ovens, stoves, and hard-to-reach areas behind or between appliances. Thoroughly clean these areas with a powerful vacuum.
- At the end of each day, remove all garbage that contains food from the building.
- 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, then place the bags into a rodent-proof dumpster or other storage receptacle.
- Keep garbage cans and dumpsters as clean as possible to deny food to ants, as well as 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 a 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 to 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, squashing or 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 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 which 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 to 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 which 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. Applicators should always wear protective equipment during applications. All labels and Material Safety Data Sheets (MSDS) 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 otherwise labeled. **Pennsylvania law allows pesticide applications in schools only by certified applicators, registered technicians, or by non-certified applicators or non-registered 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 the vicinity 72 hours prior to and for 48 hours after the application. The law also mandates a 7-hour reentry period for common access areas whenever pesticides are applied.**

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

Detergent and Water
When ants invade a classroom or food preparation area, the best emergency treatment is a mixture of 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.

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 in 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 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 and goggles during application.

Diatomaceous earth 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. These dusts also are useful in crack and crevice treatments.

Granular Applications
Granular applications, if used appropriately, can act as a temporary barrier and prevent ants from entering the school building. The material should be directed along the foundation 2 or 3 feet out onto the soil. Use only products manufactured and approved for this purpose and carefully follow the instructions on the labels.

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 are less effective than those that are slow-acting 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 sight and reach of children.

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

- Correct identification of the species of ant is essential since 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 in 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 in baits with a high water content than will ants nesting in moist environments.
- When there are several competing ant species in one area, nontarget ants may accept your 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” that come 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 cockroaches. Some baits are formulated as granules or gels that can be injected into wall voids through small holes. Gel baits also can be placed near ant trails in inconspicuous places where they will not be disturbed.

IPM for Clothes Moths and Carpet Beetles in Schools

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.

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 (see Table 2). 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 4 days to 3 weeks, or sometimes longer. If conditions are good—meaning abundant food, temperatures around 75°F, and at least 75 percent relative humidity—a new 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 2 to 4 weeks. The adults do not feed on fabrics.

TABLE 2.

Distinguishing Between Common Clothes Moths and Grain Moths

Species	Distinguishing Characteristics
Webbing clothes moth *Tineola bisselliella*	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
Casemaking clothes moth *Tinea pellionella*	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
Mediterranean flour moth *Anagasta kuehniella*	Wingspan ⅘ inch Hind wings dirty white, forewings pale gray with transverse black wavy bars Forebody distinctly raised at rest
Indianmeal moth *Plodia interpunctella*	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
Angoumois grain moth *Sitotroga cerealella*	Wingspan ⅝ inch Pale yellow forewings and gray pointed hind wings

Adapted from Olkowski, et al., 1991.

Most of the information for this chapter was modified from:
IPM for Schools: A How-to Manual. United States Environmental Protection Agency. EPA 909-B-97-001. March 1997.
Clothes Moths, The Ohio State University Extension Fact Sheet. HYG-2107-97.
Jacobs, S. B. *Clothes moths*. The Pennsylvania State University. Entomology-HP-17. 2000.

In heated buildings, female webbing clothes moths can mate and lay eggs any time during the year. The case-making 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 1/4 to 1/2 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 (see Table 3). Their bodies are covered with small scales or hairs, which are visible with a magnifying glass. Larvae are brownish, 1/8 to 1/2 inch long, and characteristically hairy or bristly.

As with clothes moths, the larval stage is the most damaging. Females lay eggs throughout the year and the eggs hatch in less than two weeks. The larvae feed for varying periods, depending upon 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.

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 scattered over the material and are usually small. 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.

DAMAGE

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 also can 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).

TABLE 3.

Important Carpet or Hide Beetles and Their Food Sources

Species	Description of Adults	Food Source
Furniture carpet beetle *Anthrenus flavipes*	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
Common carpet beetle *Anthrenus scrophulariae*	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 building on cut flowers
Varied carpet beetle *Anthrenus verbasci*	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
Black carpet beetle *Attagenus unicolor*	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 flours, pollen
Black larder beetle *Dermestes ater*	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
Larder beetle *Dermestes lardarius*	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
Hide beetle, leather beetle *Dermestes maculatus*	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
Warehouse beetle *Trogoderma variable*	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, 1992, and Olkowski, et al., 1991.

DETECTION AND MONITORING

Look for holes in fabric, larvae, moth cocoons, cast skins of beetle larvae, or insect excreta in stored materials, or for 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 Cooperative Extension county agent 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 large enough to account for the number of pests found, or if cleaning up the infestation does not seem to diminish their number, 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" are available for monitoring of the webbing clothes moth. A sex pheromone is a chemical signal that female moths give off to attract males.

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: the tiny, newly hatched larvae can crawl through any gap larger than 0.0004 inch.

Entomologist Roy Bry of the USDA Stored Product Insects Laboratory in Savannah, Georgia, suggests wrapping clean, susceptible materials in heavy brown paper and carefully sealing 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 a double bag) sealed with tape (Bry et al., 1972).

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 that cedar lumber loses its oil in only a few years (Back and Rabek, 1923; Laudani and Clark, 1954; Laudani, 1957). Moreover, commercial repellents made from cedar, cedar oil, or herbs cannot be counted on to give adequate control to protect goods (Abbott and Billings, 1935).

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 (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 the food, beverage, perspiration, and urine stains in woolens and other materials, garments should be dry 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 can 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 2 to 4 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 1 to 4 hours to kill the insects (Ebeling, 1975). Make sure there are no materials in the area that can be damaged by the sustained heating.

Exposure to Cold
Sudden changes in temperature from cold to warm can kill clothes moths. In the *Handbook of Pest Control*, Arnold Mallis (1982) suggests that "if articles infested with clothes moths were refrigerated at 18°F for several days, then suddenly exposed for a short time to 50°F, and then returned to 18°F, and finally held permanently at about 40°F, all moth life in them would be killed …. During the winter if furniture is placed outdoors at 0°F for several hours, it often results in good control." Smaller items should be bagged and moved in and out of bin-type freezers that are normally kept at 0°F. Infested items can be placed in tightly closed plastic bags in a freezer for 2 to 3 days, since few insects can withstand this temperature. After that, they can be moved for long-term storage to closets or chests at room temperature.

Removal of Animal Nests
Clothes moths and carpet beetles can sometimes move into buildings from the abandoned nests of birds, rodents, bats, bees, and wasps, as well as from 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. Mallis (1997) suggests using 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. **Pennsylvania law allows pesticide applications in schools only by certified applicators, registered technicians, or by non-certified applicators or non-registered 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 the vicinity 72 hours prior to and for 48 hours after the application. The law also mandates a 7-hour reentry period for common access areas whenever pesticides are applied.**

IPM for Cockroaches in Schools

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, and their shed skin contains allergens that can cause allergic reactions such as asthma 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. These are the German, brownbanded, American, and oriental cockroaches. The Pennsylvania wood cockroach is an occasional invader in wooded areas, but dies shortly after entering a building, and therefore is not considered a pest. Table 4 lists their important characteristics, while Figure 2 offers a pictorial key to common roach species. 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 brownbanded cockroaches are most often found in dryer classroom and office areas. American and oriental cockroaches are generally 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 brownbanded, 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). Cockroaches undergo a gradual metamorphosis during their life. An immature cockroach, or nymph, looks much like an adult, but is 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. Nymphal cockroaches 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—starch-based paints, wallpaper paste, envelope glue, and bar soaps—contain carbohydrates, and therefore are 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.

Most of the information in this chapter was modified from *IPM for Schools: A How-to Manual*. United States Environmental Protection Agency. EPA 909-B-97-001. March 1997.

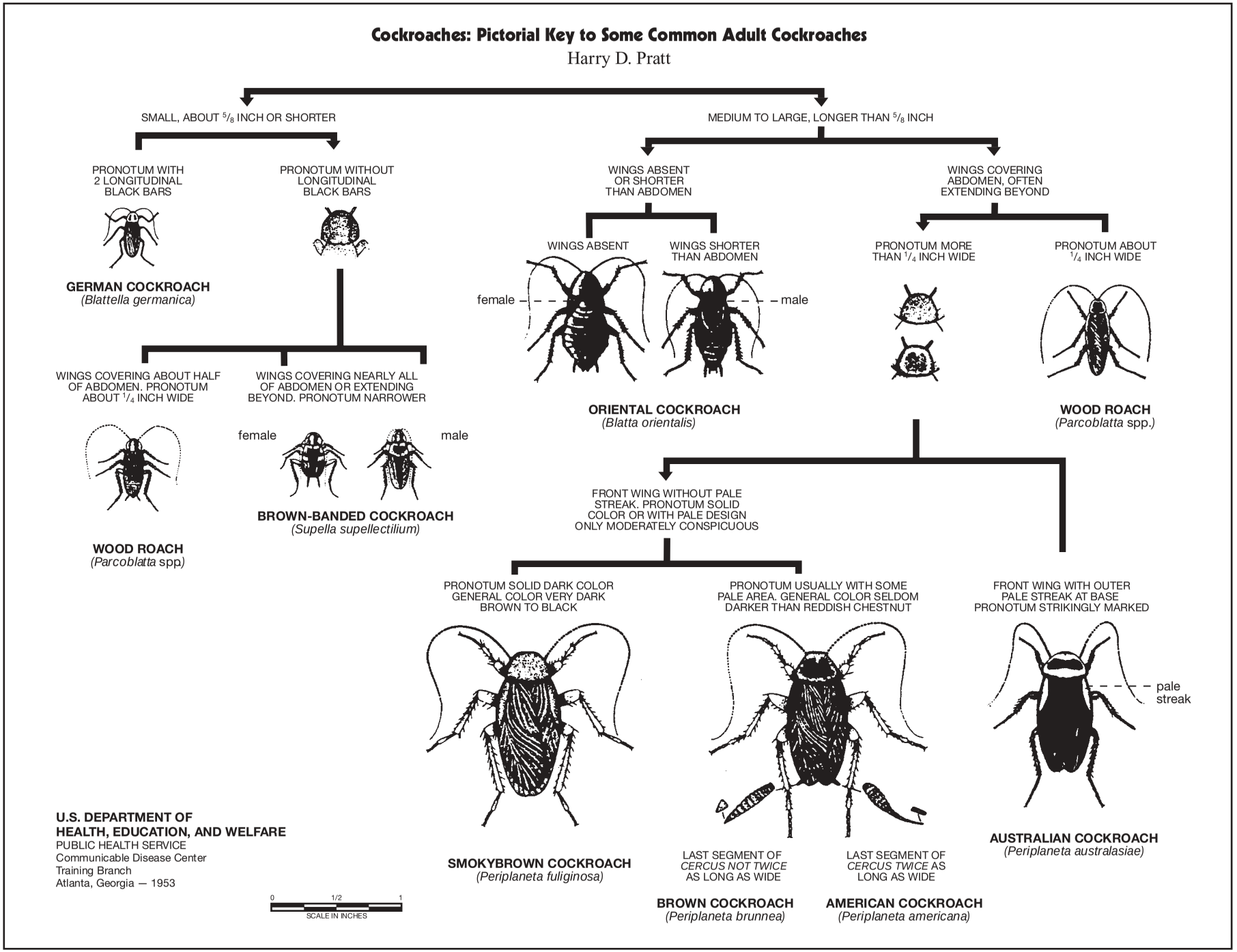
TABLE 4.

Characteristics of Common Cockroach Species

Common and scientific names	**German** *Blattella germanica*	**Brownbanded** *Supella longipalpa*	**American** *Periplaneta americana*	**Oriental** *Blatta orientalis*	**Pennsylvania wood** *Parcoblatta pensylvanica*	**Cuban** *Panchlora nivea*	**Surinam** *Pycnoscilus surinamensis*
Color and distinctive markings	Light brown with 2 black bars on the pronotum (platelike structure behind the head on the back).	Tan with faint v-shaped lighter bands on wings. Nymph has 2 distinct brown bands running crosswise on body.	Reddish brown throughout with a pale band on the edge of the pronotum.	Dark brown-black throughout. Adult male wings do not cover abdomen. Adult females are wingless.	Males chestnut brown, females black. Adult male wings cover the abdomen. Adult females have short, nonfunctional wings	Uniformly pale green. Both sexes fully winged. Good fliers.	Pronotum uniformly dark, dark olive-green wings. Wings extend beyond abdomen. No known males exist (parthenogenic species).
Length of adult	1/2 to 5/8 inch	3/8 to 1/2 inch	1 1/2 to 1 3/4 inch	1 1/4 inch	5/8 to 1 inch	7/8 to 1 inch	3/4 to 1 inch
Average # of eggs/egg case*	37	16	14	18	26	56	26
Life cycle from egg to adult	64–251 days	143–379 days	320–1,071 days	316–533 days	324–700 days	144–181 days	162–219 days
Reproduction characteristics	Female carries egg case until the nymphs hatch.	Egg case glued to ceilings, beneath furniture, or in closets; will glue egg cases on top of one another.	Egg case deposited on or near floor, usually close to food and concealed in debris. Needs high humidity to hatch.	Secures and conceals egg case in crevice; usually covers egg case with debris or sometimes with fecal pellets.	Egg case deposited only during summer, in wooded area.	Female carries egg case until the nymphs hatch.	Female carries egg case until the nymphs hatch.
Preferred habitat	Usually found in kitchen 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 • undersides of tables, kitchen equipment, and service counters • kitchen cupboards • motor compartments of refrigerators • electrical fuse boxes • spaces under broken plaster or behind sinks	Favors cracks and crevices but prefers them in warm, dry areas throughout the building. Prefers high locations in heated buildings, but also can be found: • under furniture • in appliances that generate heat • on the undersides of counters that support appliances that generate heat • in ceiling light fixtures • in telephones • in desks • behind pictures and picture frames • in boxes • in piles of debris or stored material in closets	Usually found in basements or sewers. Prefers warm, moist areas, such as: • around furnaces or heating ducts • in steam pipe tunnels • in drainage manholes and grease traps • in sewers Can live outside during warm weather.	Found in areas with excessive moisture. Found in cooler areas of a building, such as: • basements • service ducts • crawl spaces Also can tolerate hot, dry locations such as: • radiators • ovens • hot water pipes • under floor coverings Can tolerate colder temperatures, and is capable of overwintering outdoors in colder regions of the United States	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 in crevices in rural buildings. Nymphs can be active in subzero weather when exposed by pulling away bark from trees. Adults are present from May through early October.	Tropical insect. Found only in greenhouses and malls and indoor plantings. Attracted to lights.	Tropical insect. Found only in greenhouses and malls and indoor plantings. Burrows into loose soil. Active at night.

*The number actually hatched can be more.
(Modified for Pennsylvania schools from the University of Florida School IPM Web site article at **schoolipm.ifas.ufl.edu/tp4t.htm**).

FIGURE 2.


Cockroaches: Pictorial Key to Some Common Adult Cockroaches
Harry D. Pratt
SMALL, ABOUT 5/8 INCH OR SHORTER
MEDIUM TO LARGE, LONGER THAN 5/8 INCH
PRONOTUM WITH 2 LONGITUDINAL BLACK BARS
PRONOTUM WITHOUT LONGITUDINAL BLACK BARS
WINGS ABSENT OR SHORTER THAN ABDOMEN
WINGS COVERING ABDOMEN, OFTEN EXTENDING BEYOND
GERMAN COCKROACH
(Blattella germanica)
WINGS ABSENT
WINGS SHORTER THAN ABDOMEN
female
male
PRONOTUM MORE THAN 1/4 INCH WIDE
PRONOTUM ABOUT 1/4 INCH WIDE
ORIENTAL COCKROACH
(Blatta orientalis)
WOOD ROACH
(Parcoblatta spp.)
WINGS COVERING ABOUT HALF OF ABDOMEN. PRONOTUM ABOUT 1/4 INCH WIDE
WINGS COVERING NEARLY ALL OF ABDOMEN OR EXTENDING BEYOND. PRONOTUM NARROWER
female
male
BROWN-BANDED COCKROACH
(Supella supellectilium)
WOOD ROACH
(Parcoblatta spp)
FRONT WING WITHOUT PALE STREAK. PRONOTUM SOLID COLOR OR WITH PALE DESIGN ONLY MODERATELY CONSPICUOUS
PRONOTUM SOLID DARK COLOR GENERAL COLOR VERY DARK BROWN TO BLACK
PRONOTUM USUALLY WITH SOME PALE AREA. GENERAL COLOR SELDOM DARKER THAN REDDISH CHESTNUT
FRONT WING WITH OUTER PALE STREAK AT BASE PRONOTUM STRIKINGLY MARKED
pale streak
SMOKYBROWN COCKROACH
(Periplaneta fuliginosa)
LAST SEGMENT OF CERCUS NOT TWICE AS LONG AS WIDE
LAST SEGMENT OF CERCUS TWICE AS LONG AS WIDE
BROWN COCKROACH
(Periplaneta brunnea)
AMERICAN COCKROACH
(Periplaneta americana)
AUSTRALIAN COCKROACH
(Periplaneta australasiae)
U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
Communicable Disease Center
Training Branch
Atlanta, Georgia — 1953
0
1/2
1
SCALE IN INCHES

DAMAGE

Cockroaches can carry and transmit many common pathogens that cause human and animal disease (Smith and Whitman, 1992). Consequently, their presence in kitchens and cafeterias should be deemed hazardous. However, the most important health issue associated with cockroaches is the production of allergens that can cause severe bronchial problems in sensitive individuals, most notably in children and the elderly.

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, on page 35, 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:

- in 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
- the 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
- 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
- in false ceilings, vents, light fixtures, ceiling-mounted fixtures, and railings
- in 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 check-out 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

Tools Used to Inspect and Monitor for Cockroaches

Flashlight. Use a heavy-duty, corrosion-resistant model with a bright-colored body, shatterproof lens, and halogen or krypton bulb. A smaller halogen flashlight with a flexible neck is useful in tight, confined locations. Flashlight holders that can be attached to a belt are available.

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. 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** 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 (10x) 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.

Camera. A digital or Polaroid 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.

When to Inspect

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

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 (refer to Table 4 on page 35); 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:

- floors 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. Record the locations 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.

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.

Post-Treatment 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 record keeping 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 at least once a month because of the constant transport of food and packaging (which may contain cockroaches) into and out of these areas.

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 also must be informed of their responsibilities.

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 areas where traps indicate cockroaches are residing. 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.
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 that sanitation measures are maintained and to detect any incipient buildup of cockroach numbers.

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, and caulk all cracks. With good-quality materials 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.

Proper Food Storage

- Food not kept in the refrigerator should be placed in a sealed container. Cardboard boxes and paper are not cockroach-proof.
- 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.
- Glass containers with rubber gaskets or plastic containers with tight-fitting, snap-top lids are 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.
- 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- 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
- drain pipes
- 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.

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 also should 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 cracks, and schedule other building repairs to reduce cockroach habitat.
6. If traps indicate 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. **Pennsylvania law allows pesticide applications in schools only by certified applicators, registered technicians, or by non-certified applicators or non-registered 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 the vicinity 72 hours prior to and for 48 hours after the application. The law also mandates a 7-hour reentry period for common access areas whenever pesticides are applied.**
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 reduce cockroach numbers sufficiently, 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 that new infestations are detected early.

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.
- Screen drain covers in boiler rooms.
- Repair holes in window screens.
- Weather-strip around doors and windows where cockroaches may enter.
- Where gaps can't be sealed, they can be widened 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. 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 the section on chemical controls on page 43).

Thorough daily cleaning is essential.

- Sweep and mop the floors.
- Drain all sinks and remove any food debris.
- If children regularly consume snacks in classrooms, vacuum and/or mop their 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 the section vacuuming on this page).
- 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.
- 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 and dumpsters as clean as possible to deny food to cockroaches, as well as ants, flies, mice, and rats.

Brownbanded cockroaches can survive for some time without access to freestanding water, and they can live on soap or the glue on stamps, so simple sanitation alone will not have as significant an impact on a brownbanded 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. 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.

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, as well as their egg cases and droppings. A vacuum with a HEPTA filter (capable of filtering out particles as small as 0.3 microns) 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.

If the cockroach population is large, vacuuming is a way of quickly reducing 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 be sure they die.

Trapping
This 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.

Pesticides must be used in accordance with their EPA-approved label directions. Applicators should always wear protective gear during applications.

All labels and Material Safety Data Sheets (MSDS) 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 otherwise labeled.

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 (Integrated Pest Management in Schools: IPM Training Manual, 1995). Note: Do not use spray formulation insecticides around computers, because they may short-circuit the equipment. Plastic bait stations can be placed in and around computer equipment if cockroaches establish a harborage inside.

Pennsylvania law allows pesticide applications in schools only by certified applicators, registered technicians, or by non-certified applicators or non-registered 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 the vicinity 72 hours prior to and for 48 hours after the application. The law also mandates a 7-hour reentry period for common access areas whenever pesticides are applied. Contact the Pennsylvania Department of Agriculture for more information at 717-772-5203.

Management Strategies

The most recent technological advances in cockroach management have been in bait formulations and insect growth regulators (IGRs). Other currently used products include desiccating dusts. Each of these treatment methods are discussed in detail below, including how they can be incorporated into a complete integrated cockroach management program.

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. Until recently, paste baits were very messy and required application with a putty knife. However, manufacturers have improved these products by repackaging the bait material into plastic syringes that are suitable for bait gun application. This greatly improves bait placement allowing paste baits to be applied into cockroach harborages as easily as gel and dust formulations.

Currently almost all baiting products available for indoor use are formulated using one of the following active ingredients: boric acid, fipronil, hydramethylnon, 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.

Suggestions for Cockroach Baiting

(Frishman, 1994)

- Large blobs of bait in a few locations do not work well. Put out small amounts of bait in many 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 or paste baits in areas where they may get covered over with grease, flour, or dust. In areas where this might be a problem, bait stations should be used.

- 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.

Insect Growth Regulators (IGRs)

Insect Growth Regulators (IGRs) are compounds that disrupt the normal growth and development of insects. IGRs are considered safe 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 JHA, 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 4 to 9 months to achieve management. For this reason, JHAs often are combined with residual insecticides. Most of the population is eliminated by the insecticide, and immature cockroaches that survive are sterilized by the JHA.

Inorganic Dusts

Inorganic dusts, such as silica gel and boric acid, have been used frequently for cockroach management. These dusts can be applied with a bulb duster into cracks and crevices under sinks, 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 section on ants for more information about inorganic dusts.

IPM for Fleas in Schools

INTRODUCTION

Fleas can be a problem in all parts of the country except in 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 ($\frac{1}{8}$ inch long), wingless insects with powerful hind legs that are adapted for jumping and running though hair. The adult body is reddish-brown to black, oval, and laterally flattened. Unlike many other flea species, adult cat fleas remain on their host. After mating and feeding, adult female fleas lay oval, white eggs. 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, worm-like larvae ($\frac{1}{16}$ to $\frac{3}{16}$ inches 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. 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 two weeks. They can, however, remain in their cocoons 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 cocoon. 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 1 to 2 months without a meal and can survive 7 or 8 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 no pets are kept in the buildings. Adult fleas can be brought in on the clothing of staff, students, or visitors. Other possible sources include urban wildlife such as rats, feral cats, raccoons, opossums, chipmunks, squirrels, or birds that may live in unused parts of buildings. 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—also may 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

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Most of the information for this chapter was modified from:
IPM for Schools: A How-to Manual. United States Environmental Protection Agency. EPA 909-B-97-001. March 1997.
Richman, D. L. *IPM for Fleas in Schools*. Universituy of Florida School IPM Web site at **schoolipm.ifas.ufl.edu/tp5.htm**. March 1998.

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. If more fleas are caught per trap in a week, this 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.

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 1 or 2 days.

1. **Protect Yourself**. Wear long plants tucked into boots or socks. For added protection, you may want to apply an insect repellent to pantlegs 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 page 47 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 48). The IGR will prevent pre-adult fleas that survive vacuuming or steam-cleaning from maturing into biting adults. **(Pennsylvania law allows pesticide applications in schools only by certified applicators, registered technicians, or by non-certified applicators or non-registered 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 the vicinity 72 hours prior to and for 48 hours after the application. The law also mandates a 7-hour reentry period for common access areas whenever pesticides are applied.)**
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, apply a borate insecticide to carpeting or spot-treat infested areas with insecticidal soap or pyrethrin (see Chemical Controls on page 48). If adequate management has still 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 an appropriately labeled pesticide may be needed in some cases. All label directions should be followed to the letter and the applicant should wear appropriate protective clothing.
5. **Remove Any Wildlife Nesting In or Under Building**. If flea problems persist but no pet is present, check for wildlife in the vicinity of the building and remove any animals that are found. A residual insecticide may be needed under buildings to prevent flea migration indoors.

MANAGEMENT OPTIONS

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

Physical Controls

Wild Animal Removal

Wild animals can be trapped by trained animal management technicians. Consult your Yellow Pages or obtain recommendations from your Penn State Cooperative Extension county agent. 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 be either 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 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 stimulates 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.

Laundry

Wash removable floor coverings, such as rugs, located in areas where there are known infestations. Any bedding for classroom pets should 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 termites and wood-boring 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 with an insecticide labeled for outdoor use (see Chemical Controls on page 48).

Biological Controls

Beneficial Nematodes

Insect-destroying nematodes (*Steinernema carpocapsae*) can be applied to the lawn as a spray. These microscopic, worm-like 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 (Mallis, 1992).

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. **Pennsylvania law allows pesticide applications in schools only by certified applicators, registered technicians, or by non-certified applicators or non-registered 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 the vicinity 72 hours prior to and for 48 hours after the application. The law also mandates a 7-hour reentry period for common access areas whenever pesticides are applied.** Applicators should always wear protective gear during applications. All labels and Material Safety Data Sheets (MSDS) for the pesticide products authorized for use in the IPM program should be maintained on file. These materials should not be applied in common access areas when occupied, and never where they might wash into a drain or sewer unless otherwise labeled.

Insecticidal Soap

Insecticidal soap products can be found in pet stores and sometimes hardware stores. Some of these products contain pyrethrins.

Insecticidal soap can be used on pets, rugs, floors, and other places where flea eggs or young fleas may have collected. Outdoor areas also can be treated with insecticidal soap to reduce adult populations. Because this soap can kill a wide variety of insects, mites, and other arthropods (many of which are beneficial), it should be used outdoors only in spot treatments where wild animals nest, and only when flea infestations are large.

Diatomaceous Earth and Silica Aerogel

These dusts can be used for flea management. Diatomaceous earth is made from fossilized diatoms, and silica gel is produced from sand. Both of these 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 and goggles during application. Silica gel and diatomaceous earth are sometimes formulated with pyrethrins, which are discussed below.

How to Use Diatomaceous Earth and Silica Aerogel

- Lightly dust upholstered furniture that is suspected to harbor fleas. Be sure to work the material into cracks and crevices.
- Lightly dust rugs or pet bedding.
- 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 also can 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 which acts on flea larvae that have ingested it. These products may be effective for up to a year. This product is sold through veterinarians, but application of borates by a pest management professional is recommended in schools.

Imidacloprid and Fipronil

Both imidacloprid and fipronil are available through veterinarians as spot-on oils that are applied to the shoulder area of a cat or dog. These materials become

distributed over the body within a few hours. (Consult a veterinarian before using either of these products on a pet other than a cat or dog). These insecticides are relatively nontoxic to mammals and kill almost all the fleas on the pet within 24 hours of treatment. Both products continue to kill fleas for at least 30 days after treatment. However, fleas may feed, mate, and lay eggs before they die.

Pyrethrins and Synthetic Pyrethroids

There are a number of flea management products containing pyrethrins and synthetic pyrethroids which are used as spray treatments to reduce the number of fleas. These products should be applied by a 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 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 and Mosquitoes in Schools

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 characteristics shown in Table 5.

Garbage- and Manure-Breeding Flies

IDENTIFICATION AND BIOLOGY

House flies, dump flies, blue and green bottle flies, and others that breed in food wastes (garbage) and/or animal feces generally are 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, in dog or cat feces, in dead animals, in kitchen drains, in grass clippings allowed to rot in a pile, and even in 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.

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.

TABLE 5.

Common Flies Found In and Around Schools in Pennsylvania

Species	Description	Sources of Infestation
House fly *Musca domestica*	1/4–5/16 inch long; gray; 4 stripes on thorax	garbage, human and animal feces
Blow flies		
Green bottle fly *Phaenicia sericata*	1/4–5/16 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.	1/4–9/16 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*	larger than house fly, 3/8 inch long; dark gray with distinctive yellow hairs; adults sluggish	larvae parasitic on earthworms; adults enter houses in fall
Fruit fly *Drosophila* spp.	1/8 inch long; yellow-brown	fermenting fruit and vegetables, other moist organic matter
Phorid fly (Humpbacked Fly) *Megaselia scalaris*	1/16–1/8 inch long; more hump-backed in appearance than fruit flies	decomposing organic matter, including vegetables, fruit, flesh, and feces
Moth fly (Drain Fly) *Psychoda spp.*	1/16–1/4 inch long; dark or grayish with wings densely covered with hairs	eggs, larvae, and pupa often found in slime or muck in drains, sewage disposal beds, moist compost, and garbage containers; adults found near same areas

Most of the information for this chapter was modified from:
IPM for Schools: A How-to Manual. United States Environmental Protection Agency. EPA 909-B-97-001. March 1997.
Information on moth flies was adapted from Lyon, W. F. *Drain Flies*. The Ohio State University Extension Fact Sheet HYG-2071-97, and Jacobs, S. B. *Moth flies in the home*. The Pennsylvania State University. Entomology-NP-6. 1998.

DETECTION AND MONITORING

It is important to correctly identify the problem flies and pinpoint their breeding sites. Some of the characteristics listed in Table 5 can help you with identification. Specimens also can be taken to a Penn State Cooperative Extension county agent, 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 page 53 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 those flies that do get inside with a fly swatter or flypaper, 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.

Habitat Modification

Modifying 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 drains or electric garbage disposal units that leak, 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.

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.
- Wastes should be collected and moved off-site at least once a week. Since 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 borax 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 wastes 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.

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 to reduce odors that attract flies.

Flies attracted to open kitchen or cafeteria doors, or to 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 borax and water can be particularly effective); otherwise, they will continue to attract flies.

Physical Controls

Screens
Install screens over windows, doors, and vent holes to prevent flies from entering buildings. Weather-stripping 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 Swatters
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 $1\frac{1}{2}$ 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 $1\frac{1}{2}$ 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 when they begin to dry out. Flypaper can be very useful in areas where there are too many flies to kill with a fly swatter, and where 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. Traps need to be serviced regularly, placed appropriately, and repaired or replaced when damaged.

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 black light 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 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 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.

A pest management professional can help with trap placement recommendations.

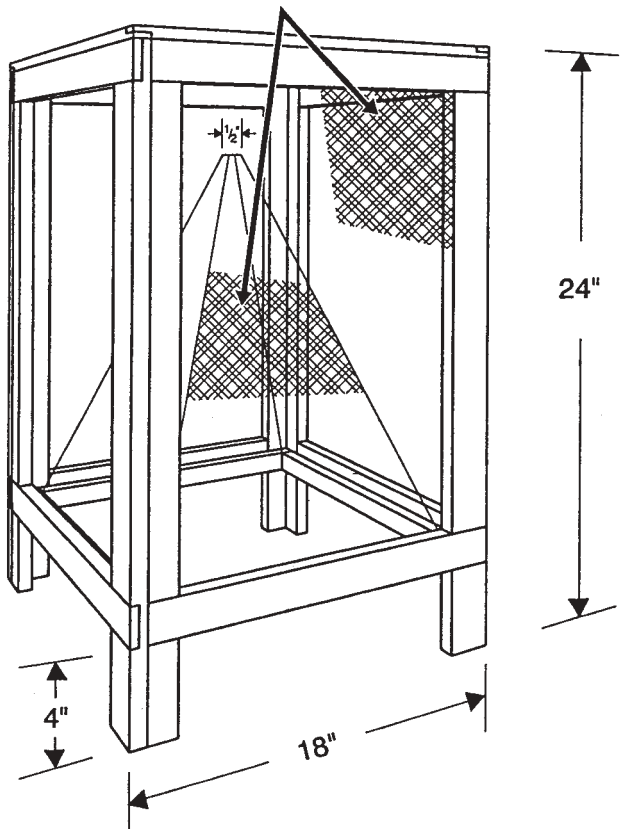
- Empty and clean the traps weekly to prevent dead flies from becoming an attractive food source for other insects.
- Replace lamps at least once a year.
- The more expensive black light "blue" bulbs do not attract more flies than regular black light bulbs.
- The lamp should be directed toward the interior 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, since 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 be easily made from wood and aluminum or plastic screening; use the dimensions shown in Figure 3. 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 can not find their way back out through the hole in the cone.

FIGURE 3.

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 also is made of screening, and should be hinged (to empty the trap) and closed with a hook and eye. Weather-stripping or a strip of foam or cloth glued to all four sides of the underside of the lid will prevent flies from squeezing out.

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 be hung over the openings of dumpsters and from buildings or fences as well. 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 and will not 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.

Fly Bait Recipes

Bait is important to the performance of the trap. Here are some recipes and tips on 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 should be kept filled with water.

LIQUID YEAST BAIT

(from Satrom and Stephens, 1979)

This recipe makes 7–9 portions of liquid bait for use with a cone trap. It can be stored 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

Use a plastic (not glass) narrow-necked gallon jug with a screw cap for mixing, ripening, and storing bait. Bleach or milk jugs work well. Wide-mouth containers will not produce effective bait.

Mix all the above ingredients in the jug. Important: With cap lightly sealed, allow mixture to begin to ripen (see ripening instructions below). It will foam up at first. After it subsides (1–2 days), tighten the lid and continue ripening till very smelly (2–9 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 4–10 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 (less than 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 off the lid 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 3 to 5 days. It attracts more flies on the first day, and then gradually declines thereafter. Don't let the bait dry out.

- 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 to 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 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 toxicant should be added.
- 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.

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 there are frequent rainstorms, it may be necessary to fit the trap with a clear Plexiglas top.

Chemical Controls

Except for odor-eliminating chemicals (such as borax) 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.

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 for rinsing out garbage cans and dumpsters. These solutions should not be used near ponds, streams, lakes, or other bodies of water, and should not be poured onto plants.

Fruit Flies, Cluster Flies, Phorid Flies, and Moth Flies

IDENTIFICATION AND BIOLOGY

Fruit Flies

Fruit 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 and cleaning rags, as well as 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 necessary at these times of the year.

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.

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.

Moth Flies (Drain Flies)

Moth flies (*Psychoda* spp.) are about 1/16 to ¼ inch long, fuzzy, dark or grayish insects. Their body and wings are densely covered with hairs. Wings, appearing too large for the body, are held roof-like 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.

MANAGEMENT OPTIONS

Fruit Flies

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.

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. Using string, hang the bottle about 5 feet above the ground. Periodically, the dead flies should be strained out and the liquid reused.

Cluster Flies

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 also can 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.

Phorid Flies

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 wall voids, under floors, in basements, or in the soil of crawl spaces.

Moth Flies

Moth flies do not bite humans, but 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 drain pipes and traps regularly to eliminate the gelatinous, rotting organic matter, thus eliminating the larval food source. Infestations developing in drains often can be eliminated by flushing these areas with sink cleaning materials followed by very hot water. Clean dirty garbage containers, standing water in air conditioners, or other sources of stagnant water in the area.

Mosquitoes

INTRODUCTION

Since the introduction of West Nile virus into the United States, the public has a heightened awareness of the importance of mosquito control. Persons most at risk from West Nile virus are the elderly and those with weakened immune systems. Not all mosquitoes carry the pathogen, nor do all people respond the same to transmission of the pathogen.

Mosquitoes also can transmit pathogens besides West Nile virus; for example, some are vectors of Eastern Equine encephalitis virus, Western Equine and St. Louis Equine encephalitis viruses, dog heartworm, and other pathogens. The three most important mosquito groups (see Figure 4) are the *Anopheles* (carrier of malaria), *Culex* (carrier of viral encephalitis), and *Aedes* (carriers of yellow fever, dengue, and encephalitis). An effective mosquito control program is essential to prevent these potential problems.

MOSQUITO LIFE CYCLE

Mosquitoes breed 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, animal tracks, and plugged rain gutters. Some mosquitoes are capable of flying many miles, so control may need to be area-wide. All mosquitoes are less than 1/2-inch long as adults.

During their life, mosquitoes pass through four distinct stages: egg, larva, pupa, and adult.

Eggs are deposited either individually or in groups called rafts on the surface of water or on soil where flooding will produce puddles or pools. Most eggs hatch within 48 hours.

Larvae are called wrigglers because of their wriggling motion in the water. The wrigglers feed on organic debris and microorganisms and breathe at the surface of the water through tubes. After molting several times as they grow, they form pupae.

Pupae are sometimes called tumblers because of their defensive motion to escape predators. They are shaped somewhat like a comma.

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.

Figure 4 shows the stages as well as characteristics that can help distinguish the three important mosquito groups.

Adult females must have a blood meal before they can lay eggs. They have elongated piercing-sucking mouth-parts used to penetrate the skin and ingest blood. The bite of the mosquito, in itself, 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 being a vector for several disease pathogens.

MANAGING MOSQUITOES

Eliminate Mosquito Breeding Sites

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

- Dispose of anything outside that can hold water, such as tin cans, containers, pots, and particularly used tires, which have become the most important mosquito breeding sites in the country.
- Drill holes in the bottoms of recycling containers left outdoors.
- Turn over wheelbarrows and other water-holding tools when not in use.
- Do not allow water to become stagnant in birdbaths, 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 more than four days.

Eliminate Adult Resting Sites

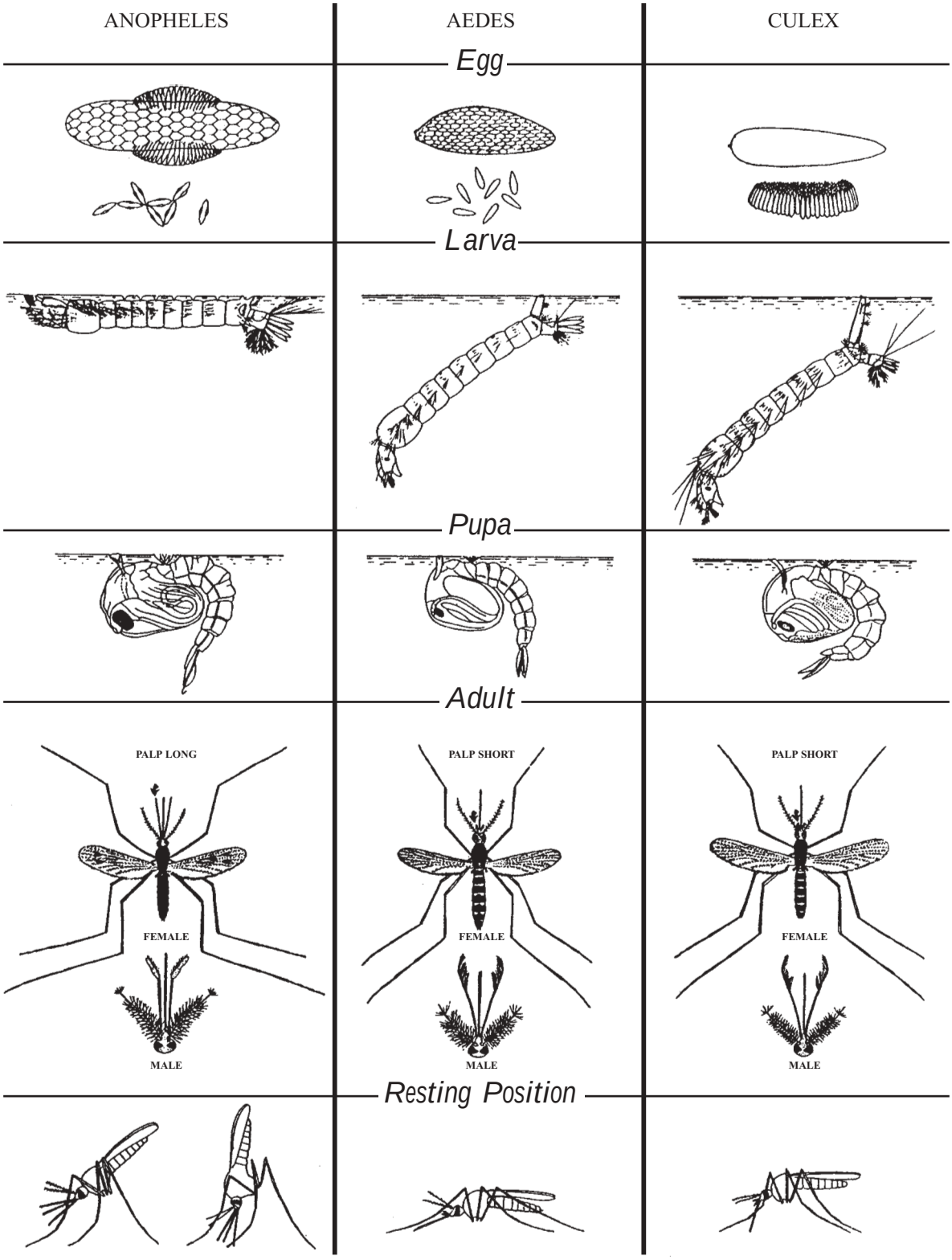
Cut back or remove dense brush and other vegetation from around buildings. Keep grassy areas mowed. Promote natural breezes to discourage mosquito occurrence.

Biological Control

Biocontrol is the use of biological organisms to control pests. Larvivorous fish are the most extensively used biocontrol agent for mosquito control. Predaceous fish, such as bluegills (*Centrarchidae*) and killifish (*Cyprinodontidae*) can be placed in permanent or semipermanent water bodies for larval control. Other biocontrol agents have been tested, but so far have generally not been operationally feasible.

Some of this material has been adapted from:
Pitts, C. W., G. L. Holbrook, S. I. Gripp and W. K. Hock. *Mosquito Biology and Control*. The Pennsylvania State University. **www.pested.psu.edu/spWNmosqbio.pdf**.
Higgins, W. *Policy and Procedures For Mosquito Control*. Western® Pest Service, Voorhees, N.J.
Proceedings of the Seventy-Sixth Annual Meeting of the New Jersey Mosquito Control Association, Inc., 1989. pp. 45–50. **www.rci.rutgers.edu/~insects/larvsurv.htm**.

FIGURE 4. Characteristics of three groups of mosquitoes



Illustrations from *Mosquito Prevention on Irrigated Farms*. 1967. USDA Ag. Handbook 319.

Avoidance

- Reduce outdoor exposure, especially at dawn, dusk, and in the early evening during peak periods of mosquito activity (April to October).
- Avoid areas where mosquitoes tend to concentrate—in tall grass, margins of wooded areas, or in heavily wooded areas in dense vegetation.
- 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.

Repellents

Apply insect repellent sparingly to exposed skin. An effective repellent will contain 20 to 30 percent DEET (*N*,*N*-diethyl-3-methyl-*m*-toluamide). Avoid products containing more than 30 percent DEET, since in high concentrations (more than 30 percent) DEET may cause side effects, particularly in children. Spray clothing with the repellent also, as mosquitoes may bite through thin clothing. (From the Pennsylvania Department of Health, **www.WestNile.state.pa.us/citizenfactsheet.htm**).

Chemical Control

Pennsylvania law allows pesticide applications in schools only by certified applicators, registered technicians, or by non-certified applicators or non-registered 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 the vicinity 72 hours prior to and for 48 hours after the application. The law also mandates a 7-hour reentry period for common access areas whenever pesticides are applied.

For most pesticides placed in water, a permit must also be obtained from the Pennsylvania Fish and Boat Commission. However the commission will allow persons to treat impounded waters with a mosquito larvicide that contains *Bacillus thuringiensis israelensis* (B.t.i.) or *Bacillus sphaericus* for waters where:

1. The water body is 1 surface acre or less.
2. The water body being treated does not have a discharge over the effective treatment period.
3. The water contains no fish (bait fish or game fish).

In general, mosquito larvae control is more effective than attempting to spray for adults. If special conditions are present, contact the Pennsylvania Fish and Boat Commission at 814-359-5147. The forms for other aquatic applications are available from regional offices of the commission, the Pennsylvania Department of Environmental Protection, the Pennsylvania Department of Agriculture, Penn State Cooperative Extension county offices, district forester offices, Pennsylvania Soil and Water Conservation District offices, or the Soil Conservation Service county offices.

Larvicides

Chemicals used to kill immature mosquitoes are typically more effective and target-specific than adulticide, yet less permanent than habitat modification. Several materials in various formulations are labeled for mosquito larviciding, including some biorational pesticides, diptera-specific bacteria, insect growth regulators (IGR), 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 must be consumed by the larvae and are usually applied well before the fourth molt to ensure consumption. IGR's must be applied later in the larvae's development 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. Give full attention to the label directions.

Adulticides

The ground or aerial application of chemicals to kill adult mosquitoes is usually the least efficient mosquito-control technique and is 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 dispersed either by truck-mounted equipment or from fixed-wing or rotary aircraft. The tiny droplets must contact the mosquitoes to be effective.

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 in 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 they will feed on any insects available rather than specialize on mosquitoes.

MONITORING FOR MOSQUITOES

The following techniques will cover most of the basic aspects of mosquito monitoring and control. Various combinations of these methods can be utilized to manage mosquitoes.

A sketch or plot plan of the school grounds is helpful in recording locations where management may be needed.

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 chemical and biological control measures.

Basic tools required for larval surveillance are: a standard, enameled, or plastic dipper about 4 inches in diameter (1 pint or 350 ml capacity), used for taking larval samples (the handle of the dipper may be lengthened by inserting a suitable piece of wood dowel or PVC pipe); a small pipette or eyedropper; a pair of boots; vials, 6 oz plastic bags or some other container for collecting larvae; labels for the collections; and a pencil.

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 to 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 one's 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 are 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 kind 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—***Anopheles* larvae are normally found at the surface of the water 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.
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.
3. **Complete submersion—**Certain Culicine 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.
5. **"Flow-in" method—**This method is useful in situations where the water is shallow, with mud, leaf litter, or other debris 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.
6. **Scraping—**This method is used in permanent or semi-permanent habitats containing clumps of vegetation, such as tussocks. Dip from the water in, towards the tussock, and end by using the dipper to scrape up against the base of the vegetation to dislodge any larvae present.
7. **Simple scoop—**This technique seems to be the one most commonly used by field personnel for larval surveillance and is frequently referred to as "the standard dipping procedure." The technique 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 date, location or site, type of habitat, climatic conditions, degree of cloud cover present, the larval or pupal density, stages present, and species (determined in the lab through identification).

An average of 5 to 7 larvae per dip may indicate a need for using a larvicide in the area.

An approximate time line to follow in a monitoring program is:

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 the pinpointing of potential areas of activity later.
2. April through June: Monitor every two weeks.
3. July through September: Monitor weekly, as this is the peak part of the season.
4. October finishes mosquito season. A sampling at this time can help access the effectiveness of the control program.

Samples and collection data can be submitted to the state or county health department. Larval and adult samples may be collected and preserved in 70 or 90 percent ethyl alcohol for identification purposes.

IPM for Head Lice in Schools

INTRODUCTION

Few conditions seem to cause as much concern and anxiety in schools 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. This section deals primarily with *Pediculosis humanus capitus,* the head louse.

IDENTIFICATION AND BIOLOGY

Head lice (*Pediculosis humanus capitus*) are wingless insects measuring about $\frac{1}{8}$ 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 jump or leap from victim to victim, but adults and newly hatched nymphs can move 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.

Eggs of lice, called nits, are glued to hairs of the head near the scalp, especially near the ears and on the back of the head. 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). 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 (*Pediculosis humanus corporis*) are practically indistinguishable from the head lice.

The chief features distinguishing them are:

- 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 $\frac{1}{16}$ inch long) than the other lice, are oval in shape, and have greatly enlarged second and third pairs of legs with large claws.

Other epidemiologic features are:

- Crab lice mainly infest pubic hair; they occasionally infest other coarse hair—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 venereal; 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 Non-Communicable Diseases, Sections 27.71 (11), § 27.71 (12), 27.72, and 27.73 are the legal basis for excluding and readmitting children to school in relation to specified diseases and infectious conditions.

§ 27.71 (11) specifically relates to *Pediculosis humanis capitis* (head lice) and provides for exclusion of students from school (public, private, parochial, Sunday, or other school or college or preschool) who have been diagnosed by a physician or are suspected of having pediculosis by

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Most of the material included in this chapter came from:
Guidelines for a School Based Program for Control of Lice Infestation and Other Related Conditions. Rev. 1986, Reprinted 1999. Pennsylvania Department of Health. H514.028P. 29 pp.
Wisconsin's School Integrated Pest Management Manual, School Pilot Program Draft. March, 1999. 258 pp.

the school nurse. Exclusion from school is for the period of time until the student is judged noninfectious by the school nurse or by the child's physician.

§ 27.71 (12) requirements for body lice (*Pediculosis humanis corporis*) are identical to the requirements for head lice. Pupils are excluded from attending school until judged non-infectious by the nurse in school or by 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).

CONTROL OPTIONS

When lice are discovered in a classroom, all children should be inspected for active lice. All members of the family of any child found with head lice also need to be checked for lice activity. Some school districts will adopt a "no nit" policy and not allow students back into the classroom with any nits remaining on the hair. Unless the problem is addressed at home, an infestation may recur.

Because of increased resistance to prescription and nonprescription treatments, head lice have become more difficult to manage, leading to more pressure on schools to provide treatments. *However, schools should not be sprayed to control head lice.*

Nonchemical Control

Treatments of the Classroom

- 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.

Personal treatments

- Because treatments do not kill 100 percent of the eggs, it is important to retreat within 7 to10 days for control. **It is important to 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.
- The use of oils such as olive oil and coconut oil have 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 Control

Chemicals should not be used within schools to control lice. Infestations result from personal contact or the sharing 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 cure. Here are some suggestions that should help prevent an initial infestation of head lice:

- Assign hooks for coats in the cloakroom.
- 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.
- Sharing of combs, brushes, or hats should be avoided.

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, P.O. Box 90, Health and Welfare Building, Harrisburg, PA 17108; call 1-877-PAHEALTH (877-72-432584); or call your district health consultant. Information also is available on the Pennsylvania Department of Health's Web site at **www.health.state.pa.us** and on the National Pediculosis Association site at **www.headlice.org/**.