

## 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.

**TABLE 4.**

**Characteristics of Common Cockroach Species**

Common and scientific names	German <i>Blattella germanica</i>	Brownbanded <i>Supella longipalpa</i>	American <i>Periplaneta americana</i>	Oriental <i>Blattia orientalis</i>	Pennsylvania wood <i>Parcoblatta pennsylvanica</i>	Cuban <i>Panchlora nivea</i>	Surinam <i>Pycnoscirtus surinamensis</i>
<b>Color and distinctive markings</b>	Light brown with 2 black bars on the pronotum (plate-like 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).
<b>Length of adult</b>	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
<b>Average # of eggs/egg case*</b>	37	16	14	18	26	56	26
<b>Life cycle from egg to adult</b>	64–251 days	143–379 days	320–1,071 days	316–533 days	324–700 days	144–181 days	162–219 days
<b>Reproduction characteristics</b>	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.
<b>Preferred habitat</b>	Usually found in kitchen and restrooms. Prefers dark voids such as cracks and crevices not more than 1/4 inch wide, especially in warm moist areas, such as: <ul style="list-style-type: none"> <li>• food preparation areas</li> <li>• undersides of tables, kitchen equipment, and service counters</li> <li>• kitchen cupboards</li> <li>• motor compartments of refrigerators</li> <li>• electrical fuse boxes</li> <li>• spaces under broken plaster or behind sinks</li> </ul>	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: <ul style="list-style-type: none"> <li>• under furniture</li> <li>• in appliances that generate heat</li> <li>• on the undersides of counters that support appliances that generate heat</li> <li>• in ceiling light fixtures</li> <li>• in telephones</li> <li>• in desks</li> <li>• behind pictures and picture frames</li> <li>• in boxes</li> <li>• in piles of debris or stored material in closets</li> </ul>	Usually found in basements or sewers. Prefers warm, moist areas, such as: <ul style="list-style-type: none"> <li>• around furnaces or heating ducts</li> <li>• in steam pipe tunnels</li> <li>• in drainage manholes and grease traps</li> <li>• in sewers</li> </ul> Can live outside during warm weather.	Found in areas with excessive moisture. Found in cooler areas of a building, such as: <ul style="list-style-type: none"> <li>• basements</li> <li>• service ducts</li> <li>• crawl spaces</li> </ul> Also can tolerate hot, dry locations such as: <ul style="list-style-type: none"> <li>• radiators</li> <li>• ovens</li> <li>• hot water pipes</li> <li>• under floor coverings</li> </ul> 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: <http://schoolipm.ifas.ufl.edu/ip4t.htm>).



## 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 Program 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 Program 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 noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. 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 noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. 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.