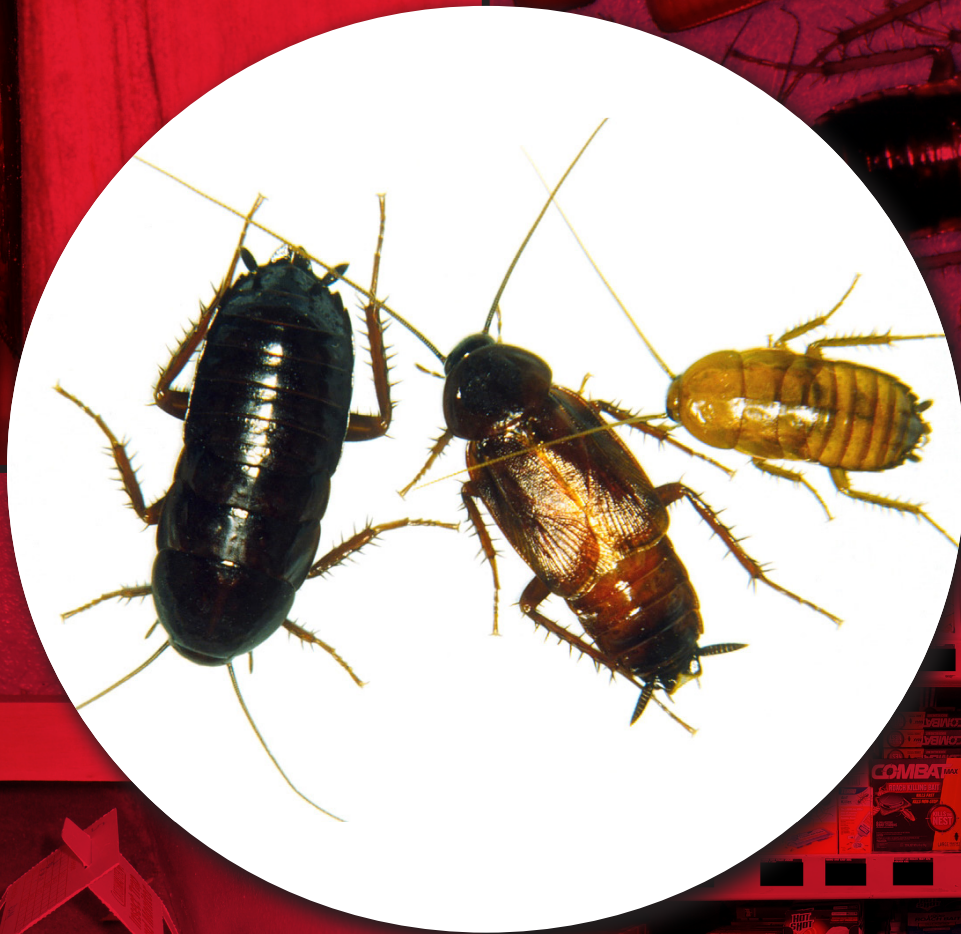
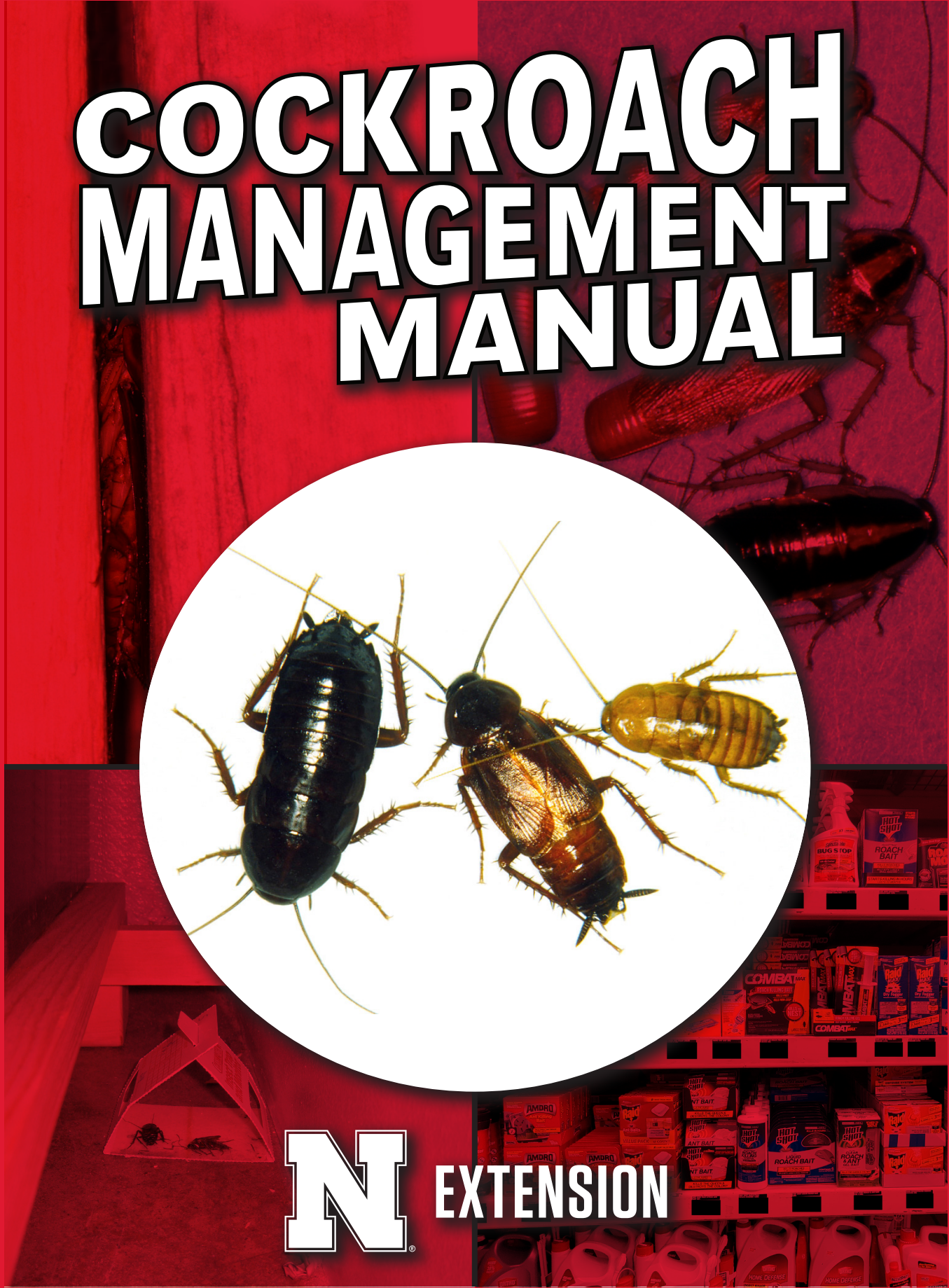


COCKROACH MANAGEMENT MANUAL



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EXTENSION





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You are responsible for using insecticides according to the current label directions and federal and state laws. Follow label directions exactly to protect the environment and people from insecticide exposure. Failure to do so violates the law.

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Chapter 1

Cockroaches and Human Health

Cockroaches are an insect that immediately causes panic in many people, mainly due to their association with filth. While some cockroaches may be incidental invaders, several species have close associations with humans and will infest homes and other man-made structures. Seventy species of cockroach are found in the United States, and of those, only 17 are considered pests of varying degrees.¹ Four species in particular, the American, brownbanded, German and oriental cockroaches, are major pests that live and breed within human dwellings. Research has suggested that infestation trends of the German and American cockroaches are on the rise.²

While the presence of cockroaches in the home causes distress, the simple truth is that cockroaches are indiscriminate; they will infest dwellings regardless of ethnic group or economic class of people. Sloppy housekeeping does not automatically mean a person will have a cockroach infestation. That being said, proper **sanitation**, is a key element in managing cockroach infestations and clean homes will not sustain as many cockroaches as dirty or cluttered homes. Other factors like high humidity, leaky faucets and other water sources, cockroach tolerability, and consumer knowledgeability are important in influencing the number of cockroaches in a dwelling.

Cockroaches commonly feed and breed in unsanitary areas including sewage systems, septic tanks, garbage, etc. Because of their connection to filth, cockroaches are also medically important reservoirs and potential vectors of **food poisoning** microorganisms, **pathogens** and disease, making the contamination of food products a high concern in infested areas. Cockroaches transmit bacterial agents

by mechanically “picking up” pathogens, often from feeding on or touching discarded food, animal feces, waste, dead insects (including each other) and other decaying materials. Bacteria can survive within the cockroach’s gut for over a month with many items including food utensils and home appliances, becoming contaminated through cockroach feces, legs and mouthparts. Cockroaches have been implicated in the transmission of approximately 50 different microorganisms including Salmonella, Staphylococcus, Streptococcus, coliform and other pathogens.³ German cockroaches, for example, have been implicated in the transmission of several intestinal diseases such as cholera, diarrhea and dysentery. Additionally, cockroaches have also been reported to spread six species of parasitic worms, fungal agents, rotavirus and other parasitic microorganisms.⁴

Additionally, cockroaches may trigger serious **allergic reactions** in sensitive individuals due to allergens from cockroach, feces, saliva and shed exoskeletons. When exposed to dust in cockroach-infested homes, children and adults can develop allergic symptoms such as runny nose, itchy eyes, and sneezing. Sensitization to cockroach allergens occurs by the inhalation of airborne allergens or ingestion of cockroach-contaminated food. Some people who are allergic to cockroaches may also develop **asthma**, a chronic lung disorder characterized by obstruction of airways. Research has shown that 23-60% of urban dwellers with asthma are allergic to cockroaches and children who grow up in cockroach-infested apartments have higher rates of asthma, more missed school day, and more doctor visits.⁵ A single intervention for cockroach control has been shown to reduce asthma

1 Atkinson, “Catalog and Atlas of the Cockroaches (Dyctioptera) of North American North of Mexico”; Brenner and Kramer, “Chapter 6 - Cockroaches (Blattaria).”

2 Nasirian, “Infestation of Cockroaches (Insecta).”

3 Barcay, “Chapter 2 - Cockroaches.”

4 Fotedar, Banerjee, and Verma, “Cockroaches (*Blattella germanica*) as Carriers of Microorganisms of Medical Importance in Hospitals”; Tetteh-Quarcoo et al., “Microbial Carriage of Cockroaches at a Tertiary Care Hospital in Ghana”; Oyeyemi, Agbaje, and Okelue, “Food-Borne Human Parasitic Pathogens Associated with Household Cockroaches and Houseflies in Nigeria.”

5 Portnoy et al., “Environmental Assessment and Exposure Reduction of Cockroaches.”

morbidity in children.⁶

There is no singular secret to a cockroach's success. In fact, there are many factors that allow them to be such successful, albeit difficult, pests.

Cockroaches:

- Are small in size;
- Are active at night and in dark areas away from human activity;
- Use chemical signals to aggregate or group together;
- Can live for more than a year;
- Reproduce in high numbers relatively quickly;
- Utilize protective egg cases (impenetrable to insecticides);

- Adapt to their environment;
- Feed on a large variety of food resources;
- Can develop resistance to conventional insecticides;
- And can avoid other management attempts such as lures and baits.

The risk of disease, food poisoning, allergies and asthma, compounded with the infestation itself, reinforces the need for proper management of cockroaches in homes. In this manual, we will discuss important practices in the prevention and management of cockroach pests.

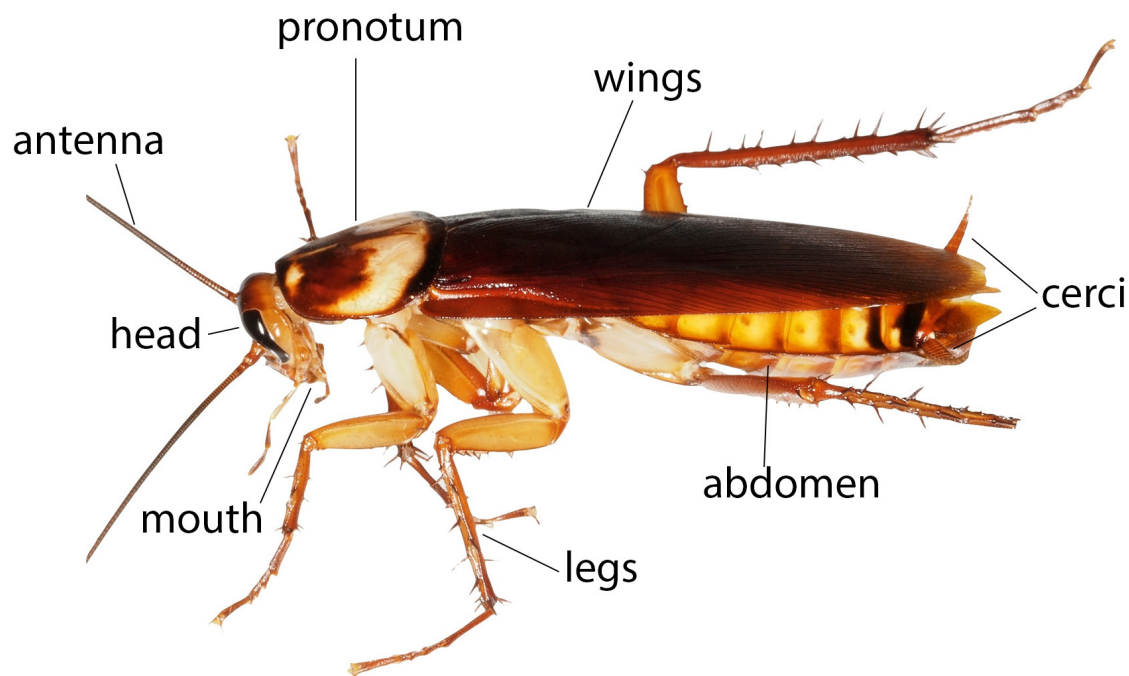


Photo courtesy of UNL Entomology

Figure 1. The basic cockroach body showing the antennae, head, mouth, pronotum, legs, wings, abdomen and cerci.

⁶ Rabito et al., "A Single Intervention for Cockroach Control Reduces Cockroach Exposure and Asthma Morbidity in Children."

Chapter 2

Know Your Enemy – Cockroach Identification & Biology

Identifying the correct species of cockroach is an essential **first step** in any management program. Different cockroach species have different life cycles, behaviors, and habitats; understanding each of these can help you cater specific control tactics that best work for each species. Contact your local Extension office for assistance in identifying different species of cockroaches.

2.1: Appearance

Like most insects, cockroaches have three primary body regions consisting of the head, thorax and abdomen. Cockroaches also have oval-shaped bodies, threadlike antennae, a head hidden behind a large shield-like pronotum, six pairs of running

legs, chewing mouthparts, leathery wings (when present) and a pair of cerci (**Figure 1 on pg. 6**). Cerci are small appendages at the end of their abdomen that help them sense vibrations in the air and ground. While wings may be present in adults of some species, adults of others may have short, rudimentary wings and appear wingless upon first glance. Small bristles and soft hollow lobes on the cockroach’s feet also act as adhesive organs to allow cockroaches to climb and stick to many surfaces.

The majority of cockroach species are flattened in appearance and range in color from brown to black. Colors or markings on the pronotum, wings and abdomen can sometimes help distinguish different species (**Figure 2; Table 1**).

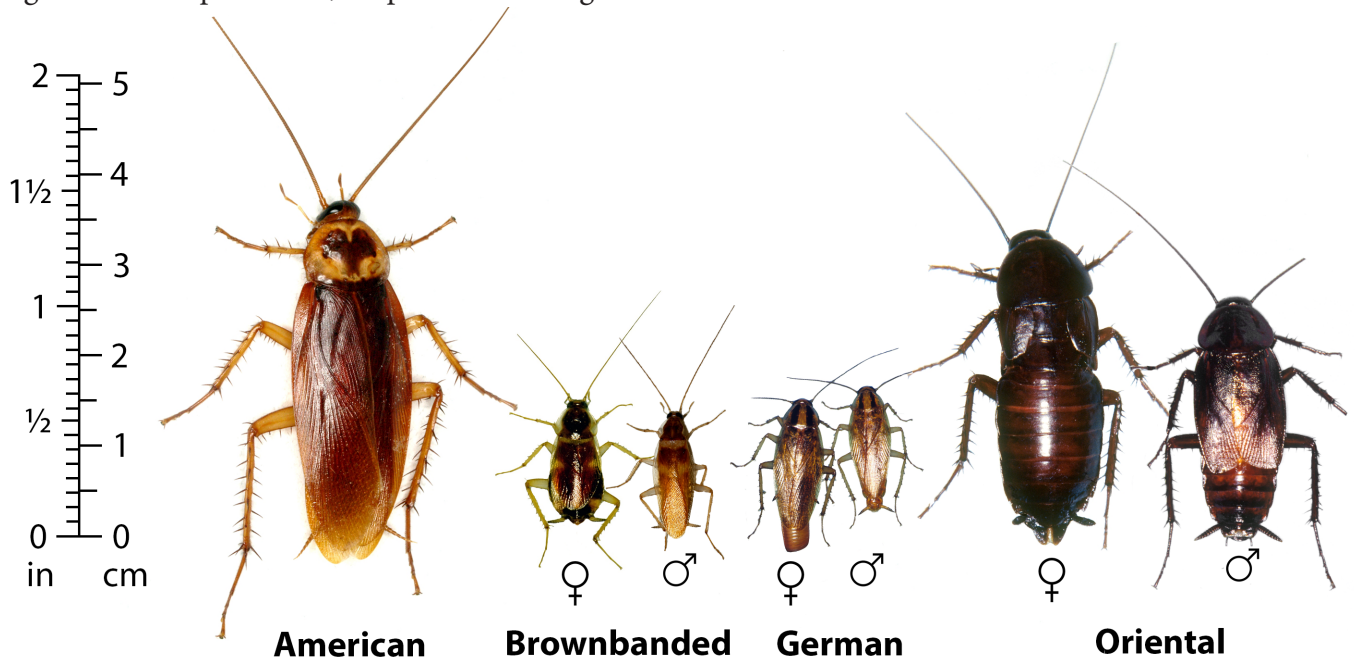


Figure 2. Size comparison of four cockroach species commonly found inside homes. From left to right: American cockroach adult, brownbanded cockroach adult female, brownbanded cockroach adult male, German cockroach adult female with protruding egg case, German cockroach adult male, , oriental cockroach adult female, oriental cockroach adult male (images courtesy of UNL Entomology).

Table 1. Visual characteristics comparing four different cockroach species commonly found inside homes.

Cockroach species	Adult length (approx.)	Identifying characteristics
American <i>Periplaneta americana</i>	1½ inches (38 mm)	<ul style="list-style-type: none"> • Reddish brown with an “M” marking behind their head • Adults possess long wings that cover the abdomen • Nymphs are wingless and lighter in color than the adults
Brownbanded <i>Supella longipalpa</i>	½ inch (14 mm)	<ul style="list-style-type: none"> • Distinct horizontal yellow bands along their wings • Adult male has a golden-brown body with wings longer than the abdomen • Adult female has a dark brown, tear-drop shaped body with wings shorter than the abdomen • Nymphs have two horizontal pale bands on body
Oriental <i>Blatta orientalis</i>	1¼ inches (32 mm)	<ul style="list-style-type: none"> • Dark brown to black • Adult males have wings which are shorter than the abdomen • Adult females have short, rudimentary wings • Nymphs are wingless and lighter in color than the adults
German <i>Blattella germanica</i>	½ inch (14 mm)	<ul style="list-style-type: none"> • Adults are light brown with two dark longitudinal bands behind the head • Adults have fully developed wings • Nymphs are wingless with dark longitudinal stripes along their back

2.2: Life Cycle

All cockroaches undergo a gradual metamorphosis with three life stages: egg, nymph (immature) and adult. Egg cases, called **ootheca**, are brown in color and symmetrical, with eggs lined up in two equal rows. Depending on the cockroach species, egg cases may be deposited onto surfaces (external embryonic development) or retained within the female, partially hanging out of the end of her abdomen (internal/extruded embryonic development). Egg cases can also differ from species to species in appearance and number of offspring (Figure 3).

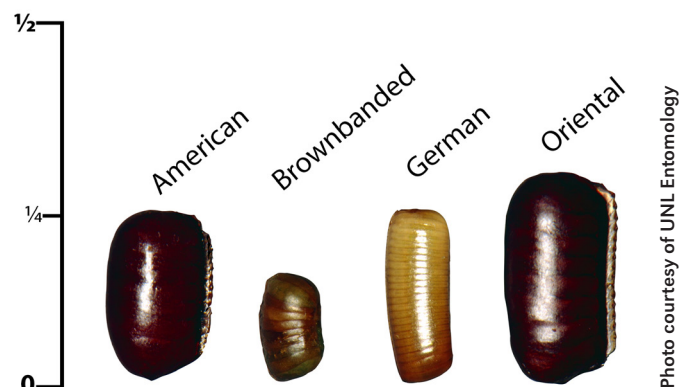


Figure 3. Egg cases of the four domestic cockroaches.

Photo courtesy of UNL Entomology

Nymphs resemble adults, but are smaller in size and lack wings. Insects shed their exoskeleton and undergo a series of molts during their development. Occasionally, a home owner will come across a white cockroach. No—these are not albino roaches—these are simply cockroaches that have recently molted and their new exoskeleton has not yet hardened or darkened (Figure 4). Within a couple of hours, newly molted cockroaches will have normal looking, dark exoskeletons.



Figure 4. Recently molted cockroach.

The time it takes a cockroach to fully develop from egg to adult depends on many factors including temperature, nutrition and species. The number of nymphal instars or molts a cockroach undergoes, depends on the species, as does the number of eggs and behavior (Table 2). Each of these are important factors in managing pests. In this section, we will further discuss the biology and behavior of the four domestic cockroach species highlighted in the manual.

Different species of cockroaches also leave differing patterns of fecal specks and smears. (Figure 5) These, combined with the presence of live or dead cockroaches, are signs of cockroach infestation that can help identify both the cockroach species and the level of infestation.

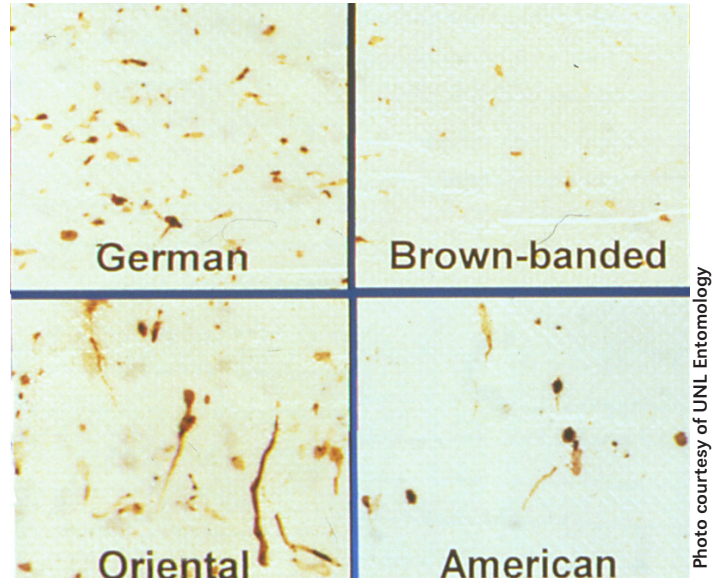


Figure 5. Fecal specks and smears of the four domestic cockroaches.

2.3: German Cockroach (*Blatella germanica*)

Life Cycle

German and oriental cockroaches are the most common found in North America. Reproductive

Table 2. Life histories of four selected cockroach species (adapted from Brenner and Kramer 2019).

Cockroach species	Number of eggs/ootheca	Number of nymphal instars	Developmental time (days)	Reproductive characteristics
American	12-16	10-13	180-700	External
Brownbanded	14-18	6-8	90-276	External
German	30-40	5-7	103	Internal/External
Oriental	16	7-10	206-800	External

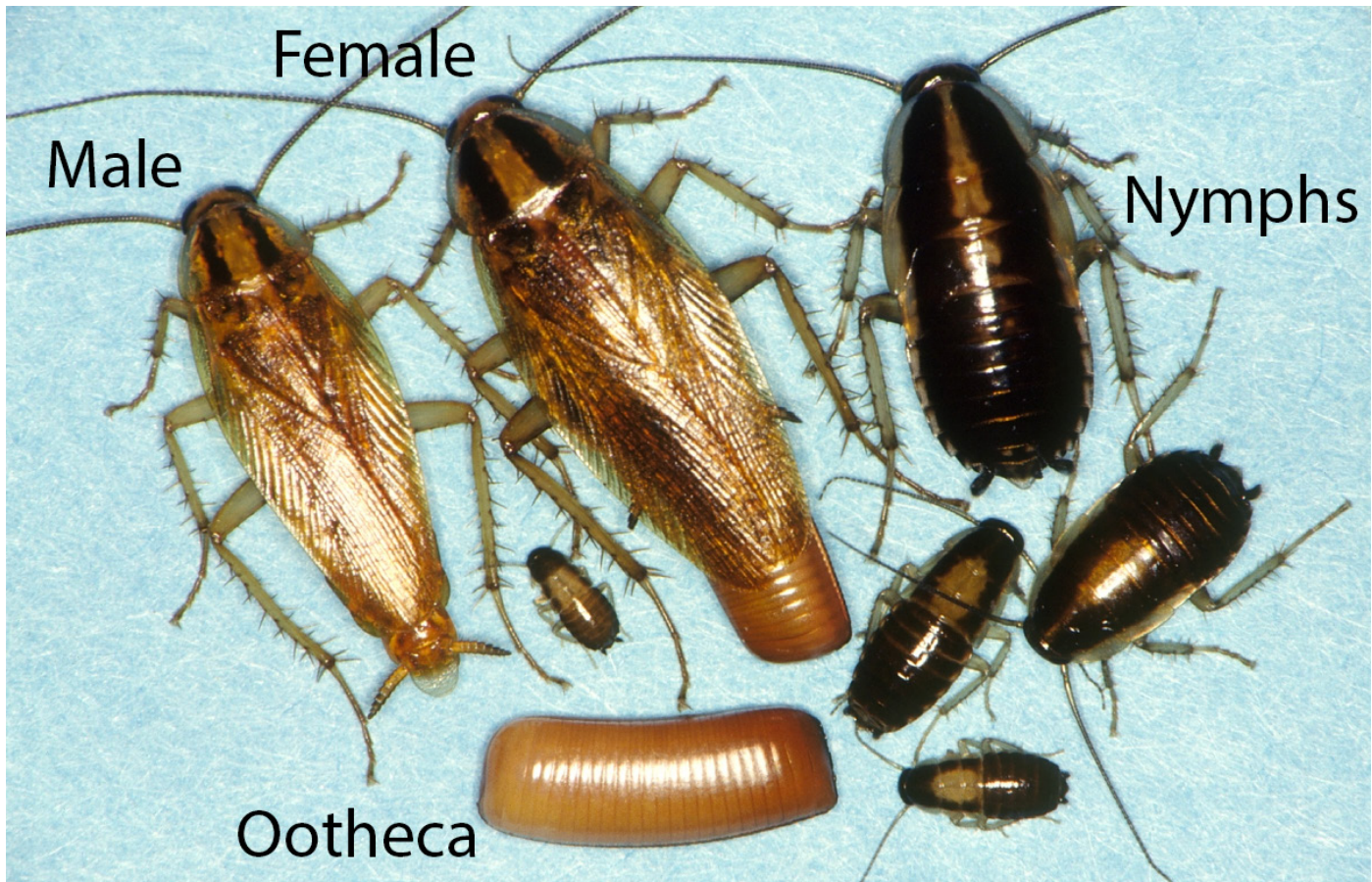


Photo courtesy of UNL Entomology

Figure 6. German cockroach adults, nymphs and egg case.

females may be seen with egg cases protruding (gravid female) from the end of her abdomen. She will carry the egg case for approximately three weeks until they are ready to hatch, and then deposit it in a sheltered area often away from other cockroaches to decrease the likelihood of cannibalization. In comparison with the other three species highlighted in this manual, the German cockroach has a tremendous capacity to produce offspring with a large number of eggs per egg case and a relatively short development time. A female German cockroach can live approximately 6-7 months and can produce as many as eight egg cases and approximately 240 offspring in her lifetime. Populations generally increase during summer months. (Figure 6)

Behavior and Habitat

German cockroaches are considered domestic, meaning they breed throughout the year indoors.

Infestations are often associated with poor sanitation, particularly around food-handling areas. This is because German cockroaches aggregate in warm, humid and dark places with ample food and water, such as kitchens and bathrooms. This aggregation behavior is due to a pheromone in the cockroach's feces used to attract others. Immature German cockroaches will feed on the feces of adults and do not need to venture far to find food. This means there are more cockroaches hiding (in harborage areas) than those that are actually seen. German cockroaches are commonly found in and around:

- Cracks and crevices of countertops
- Wall and ceiling voids
- Refrigerators
- Dishwashers
- Stoves
- Dryers
- Water heaters
- Bathroom fixtures

Gravid females of the German cockroach are often the hardest to kill. Females carrying fully developed egg cases will eat less until the egg cases are deposited. This means that she is less likely to consume a bait or forage and come into contact with a residual insecticide.

German cockroach infestations are more common than those of the brownbanded cockroach. While German cockroaches have been known to outcompete other cockroach species, they can coexist with American cockroaches in infested homes.

2.4: Brownbanded Cockroach (*Supella longipalpa*)

Life Cycle

Gravid females will carry egg cases for approximately two days before gluing them to inconspicuous places including furniture, walls and even ceilings. A single female lives for about 6-7 months and can produce about 250 offspring in her lifetime. However, the time required to reach maturity is longer than that of the German cockroach and eggs of the brownbanded cockroach are more susceptible to the environment (drying out, cannibalism, etc.) due to being deposited in open areas. Regardless, brownbanded females produce more egg cases during the summer months than other times of the year. (Figure 7)

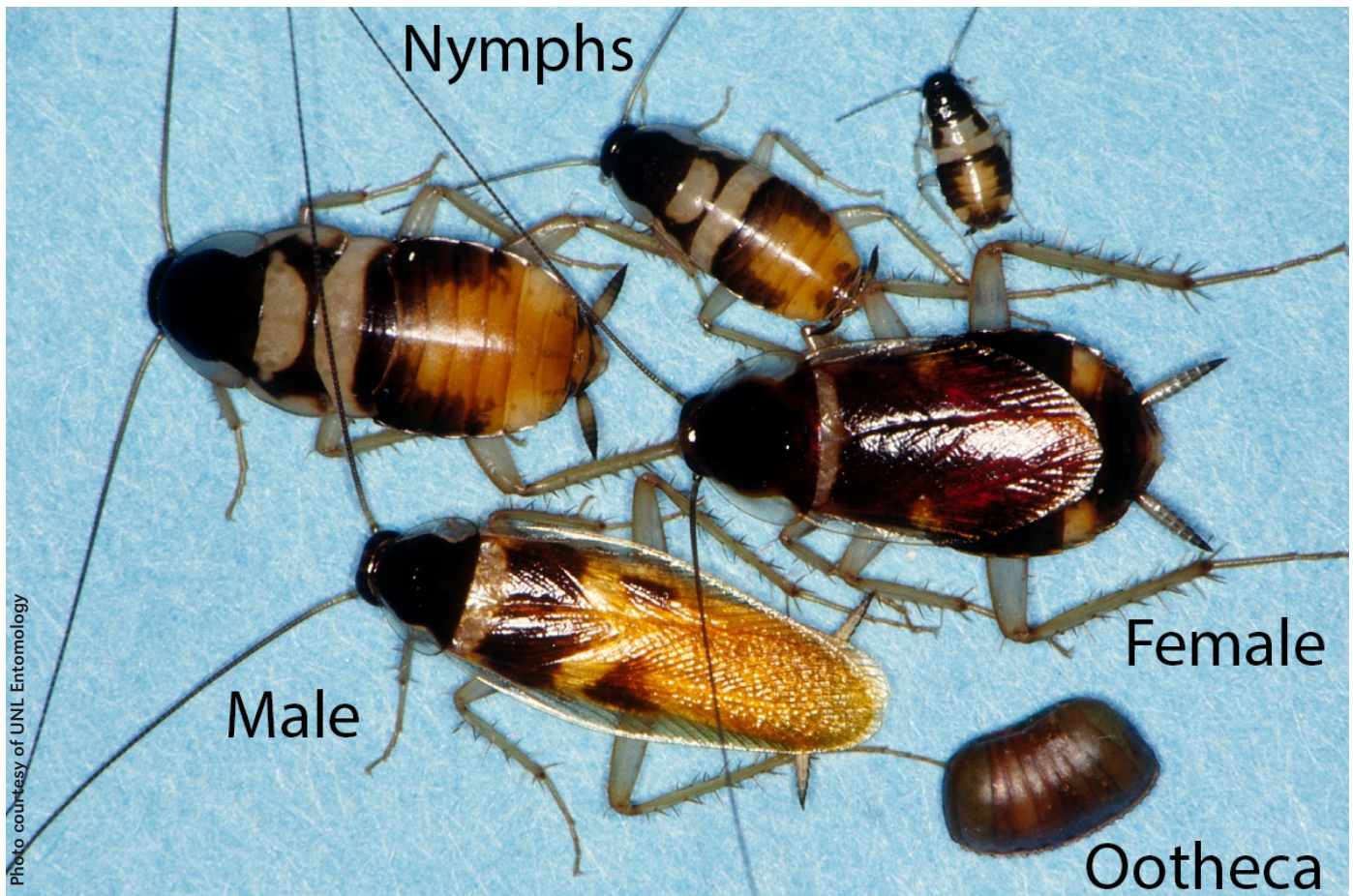


Figure 7. Brownbanded cockroach adults, nymphs and egg case.

Behavior and Habitat

Similar to the German cockroach, brownbanded cockroaches are also considered domestic and depend on indoor human dwellings for food, water and harborage, though they are far less prevalent. Different from the German cockroach, however, is their tendency to aggregate in warmer areas, higher off the floor and away from water sources. Brownbanded cockroaches build up their highest populations in areas of high temperatures and do not require as much water as German cockroaches do. Harborage preferences for the brownbanded cockroach include:

- Cabinets
- Closet shelves
- Behind pictures
- Refrigerator motors
- Electronics
- Television sets

Because of this behavior, conventional control strategies that focus on ground areas are not as effective against brownbanded cockroaches.

2.5: Oriental Cockroaches (*Blatta orientalis*)

Life Cycle

A female oriental cockroach can produce up to five egg cases in her lifetime, with each egg case housing approximately 16 offspring. Within two days of producing an egg case, females deposit them in sheltered areas abundant with food. Female oriental cockroaches can live 5-6 months and produce a total of 80 offspring. Mating occurs anytime during the year, but nymphs or immature oriental cockroaches are most common in the late-spring until mid-summer. (Figure 8)

Behavior and Habitat

Oriental cockroaches are sometimes called “waterbugs” due to their affinity for humid, moist areas. Outdoors, these are areas with high organic matter like wood chips, mulch and soil. Indoors, oriental cockroaches are commonly found in:

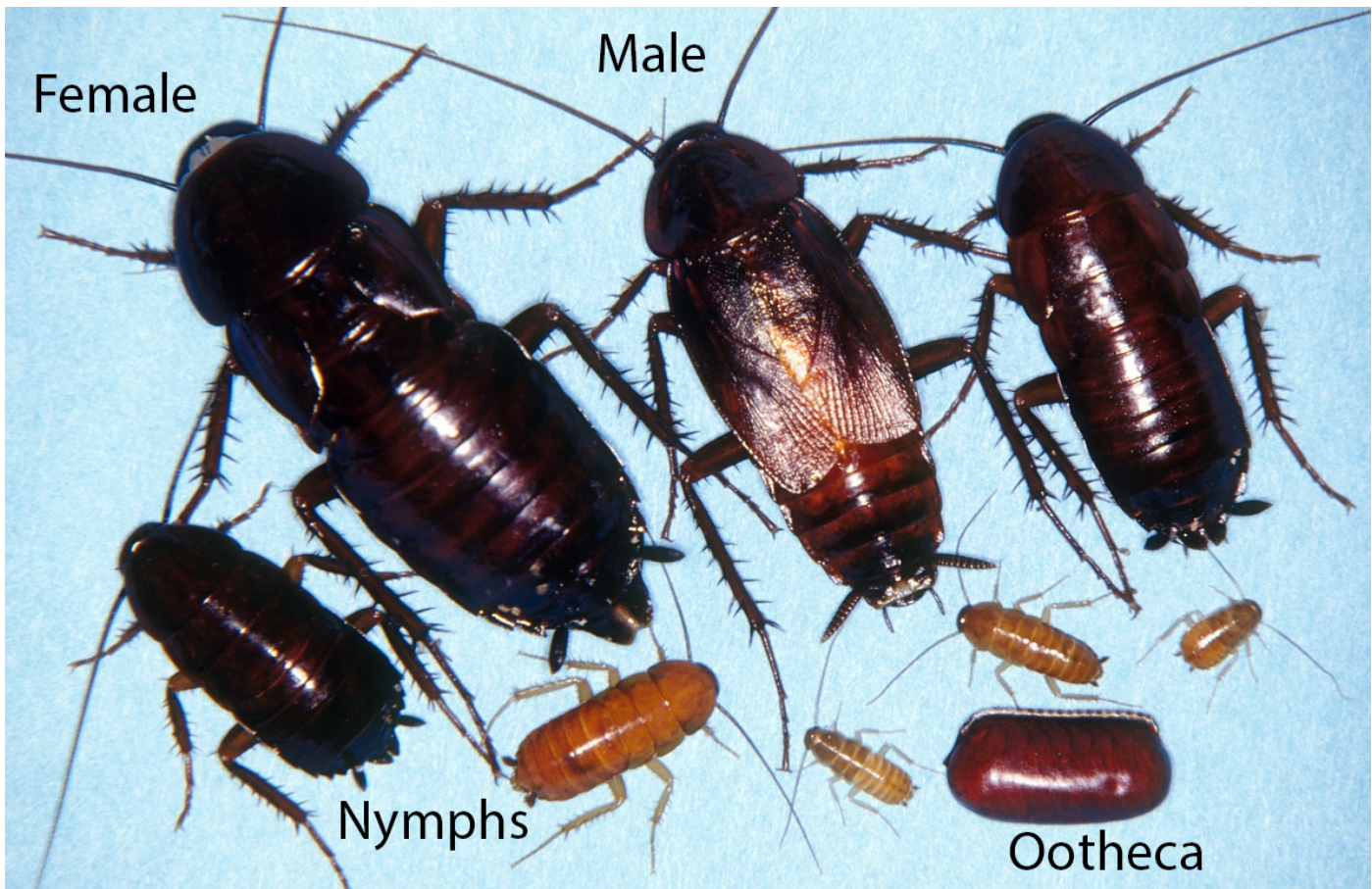


Figure 8. Oriental cockroach adults, nymphs and egg case.

- Basements
- Bathrooms
- Floor drains
- Crawl spaces
- Exterior foundations under concrete slab
- Areas with moisture issues

Unlike German and brownbanded cockroaches, oriental cockroaches can live primarily outdoors. They will often move indoors during hot, dry periods as they prefer temperatures below 84°F (29°C). Oriental cockroaches have exhibited cold tolerance and can survive winters with access to food and water.

2.6: American Cockroach (*Periplaneta americana*)

Life Cycle

American cockroaches are the largest cockroach species in the United States. Gravid females may hold an ootheca for hours to days before depositing

them in protected crevices or workable material. Adult female American cockroaches lay egg cases containing about 14 offspring, which take about 18 months to reach maturity. In total, an adult female can produce approximately 430 offspring in her lifetime (Marriott et al. 2019). (Figure 9)

Behavior and Habitat

American cockroaches favor warm, moist places and are typically found in sewers, basements and ground floors. In northern states, they are abundant in many cities' sewer systems. In homes, they are most common in:

- Boiler rooms
- Heated steam tunnels
- Basements
- Under water heaters
- Around pipes
- In wet floor drains

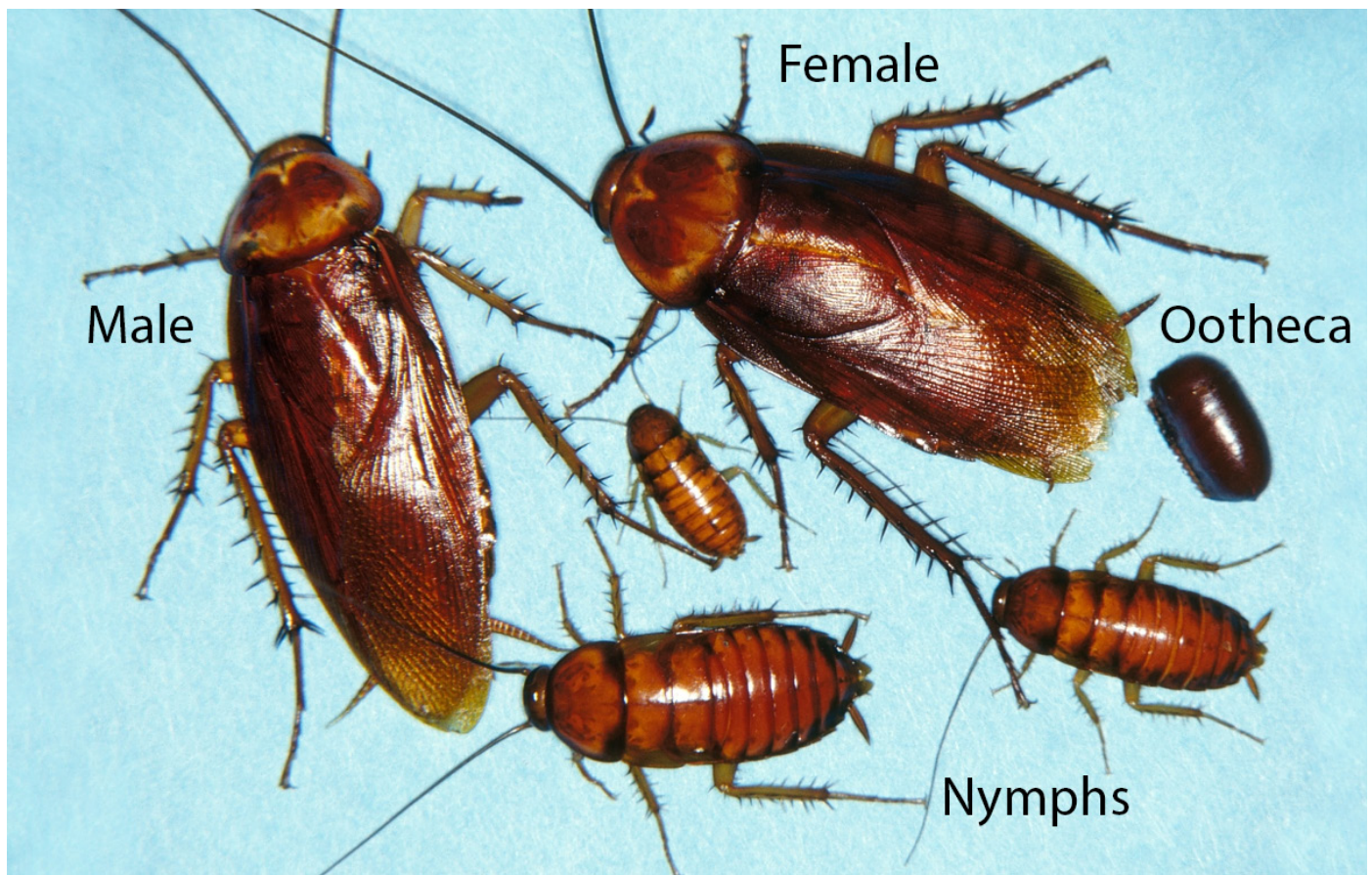


Figure 9. American cockroach adults, nymphs and egg case.

2.7: Wood Cockroaches (*Parcoblatta* spp.)

While American, brownbanded, German and oriental cockroaches are the most common species encountered in homes, wood cockroaches are sometimes found indoors. Wood cockroaches are considered incidental invaders because they cannot reproduce indoors and therefore, will not reach infestation levels. Winged males are attracted to lights and may accidentally invade homes, where they will soon die.

Some female wood cockroaches lacking developed wings resemble oriental cockroaches. Adult males have wings that extend all the way to the end of their abdomen. In oriental cockroaches, male wings are shorter and leave a portion of the abdomen exposed. In addition, adults of the Pennsylvania wood roach have a pale or transparent border on the pronotum and wings. (Figure 10)

2.8: Other Cockroaches

While the American, brownbanded, German

and oriental are the most common species encountered in the United States, there are several other cockroach species that may infest human dwellings throughout the world:

- Smokybrown cockroach (*Periplaneta fuliginosa*)
- Brown cockroach (*Periplaneta brunnea*)
- Australian cockroach (*Periplaneta australasiae*)
- Field cockroach (*Blatella vaga*)
- Asian cockroach (*Blatella asahinai*)
- Little gem cockroach (*Euthlastoblatta gemma*)
- Spotted Mediterranean cockroach (*Ectobius pallidus*)
- Palebordered field cockroach (*Pseudomops septentrionalis*)
- Argentine cockroach (*Ischnoptera bilunata*)
- Turkestan cockroach (*Blatta lateralis*)
- Florida woods cockroach (*Eurycotis floridana*)
- Surinam cockroach (*Pycnoscelus surinamensis*)
- Madeira cockroach (*Leucophaea maderae*)
- Cinereous (lobster) cockroach (*Nauphoeta cinerea*)
- Cuban cockroach (*Nauphoeta cinerea*)



Photo courtesy of UNL Entomology

Figure 10. Wood cockroach adults, nymphs and egg case.

Chapter 3

Management

When it comes to reducing or eliminating pests in the home or field, an **integrated pest management** (IPM) approach that combines a variety of techniques is the most effective, low-risk and cost-effective method. Urban IPM, or IPM inside homes, offices and buildings aim to completely eliminate pests as most of the public has zero tolerance for pests like cockroaches and bed bugs. Two of the main goals of urban IPM are to 1) manage pests, and 2) reduce pesticide usage. In fact,

use of IPM in control for cockroaches significantly reduces insecticide residue concentrations in homes.⁷ By understanding the cockroach's life cycles and behavior, we can develop a science-based plan to manage them.

IPM can be broken down into five primary steps (adapted from ESA's "What is IPM?" infographic):

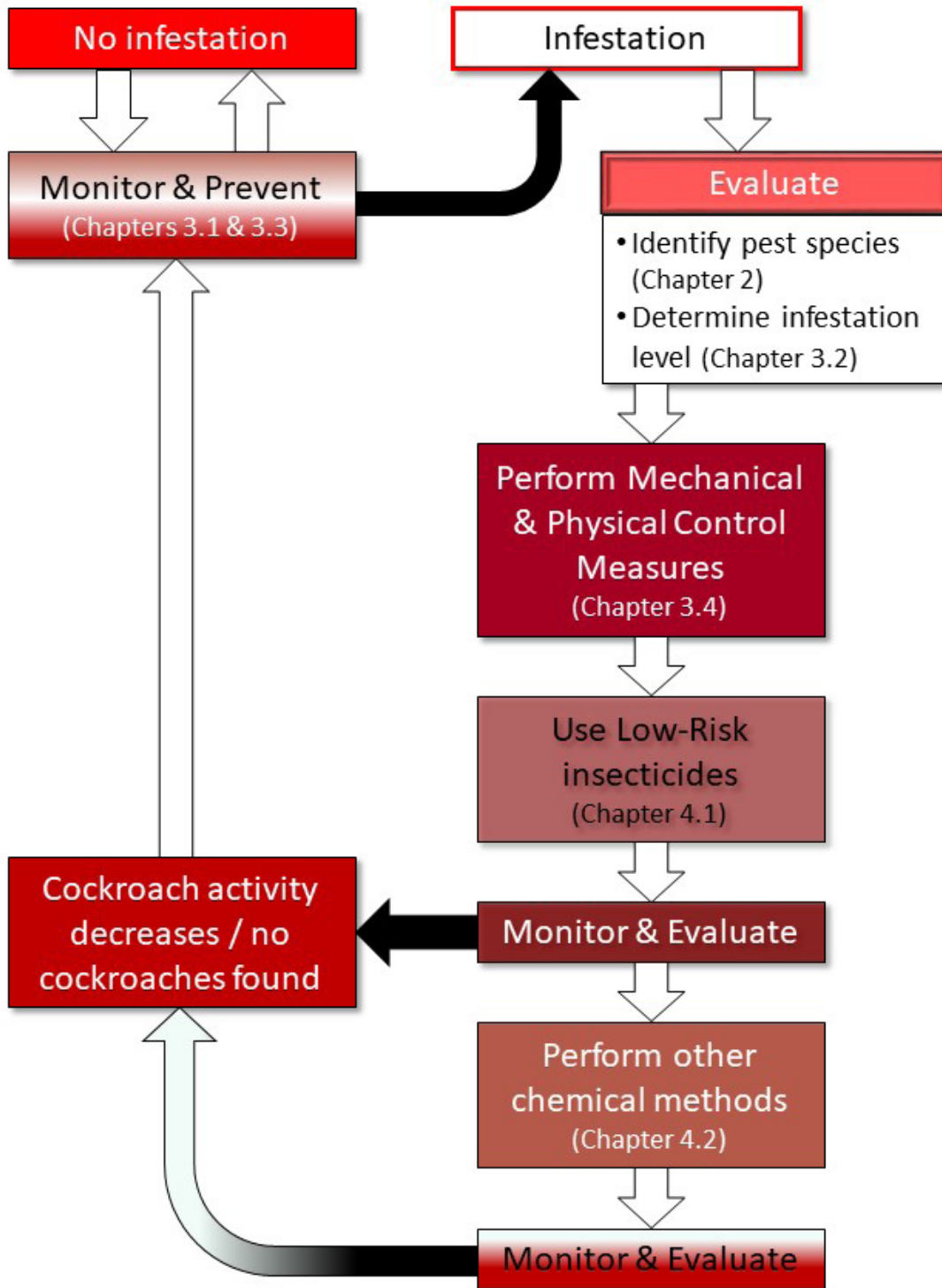
- **Identify** your pest;
- **Monitor** to determine the level of infestation;
- **Prevent** further or future infestations by using



Photo courtesy of UNL Entomology

Figure 12. American cockroach in the crevice of a cabinet drawer.

⁷ Zha et al., "Pest Prevalence and Evaluation of Community-Wide Integrated Pest Management for Reducing Cockroach Infestations and Indoor Insecticide Residues"; Wang et al., "Changes in Indoor Insecticide Residue Levels after Adopting an Integrated Pest Management Program to Control German Cockroach Infestations in an Apartment Building"



Adapted from Oi et al. 2017

Figure 11. Flowchart depicting how to prevent and approach cockroach infestations using IPM methods.⁸

⁸ F.M. Oi et al., "Assessment-Based Pest Management of German Cockroaches."

- barriers or sanitation;
- Initiate your **action** plan; use IPM tools to manage pests;
- Continue to **monitor** the population to **evaluate** your IPM treatments.

Here, we'll go into detail about each step of the IPM process as well as the IPM tools that are effective in eliminating cockroach pests in homes and buildings (**Figure 11**).

3.1: Monitor

Monitoring for pests improves the efficacy of pest control and eliminates unneeded insecticide applications. To monitor for cockroaches, you will need a flashlight to illuminate dark areas, a mirror to help see hidden areas and monitoring traps, such as glue boards.

As you begin your search for cockroaches, keep in mind what you should look for, including live cockroaches, dead cockroaches, molted exoskeletons, feces and egg cases. Use your flashlight and mirror to look in hard-to-see areas where cockroaches like to hide, including in or around:

- Countertops & cupboards (**Figure 12**)
- Kitchen appliances
- Electronic devices (**Figure 13**)
- Mops and brooms
- Floor and sink drains (**Figure 14**)
- Wheels of mobile carts or chairs
- Planters
- Pet water dishes
- Fish tanks
- Corrugated cardboard boxes
- Stacks of paper
- Behind pictures
- Suspended ceilings

Cockroaches will be in hard-to-reach areas that are often dirty. Be prepared and wear the appropriate clothing such as gloves, knee pads and potentially a hard hat.

Another valuable tool for monitoring for cockroaches is **sticky traps**. The use of traps allows you to get a better picture of the size and location of the cockroach infestation. Because cockroaches are nocturnal and prefer dark places, traps can be placed in dark areas to monitor for cockroach activity. They should also be placed in areas that are retrievable, protected from damage and inaccessible



Figure 13. Brownbanded cockroach infestation inside a telephone.

to pets and children. There are many different sticky trap designs available on the market. Different traps may have different catch rates and varying degrees of performance success in terms of attractiveness and capture.⁹ Utilize different trap types to see what works best for your situation.

Both baited and unbaited sticky traps are available. Unbaited sticky traps are usually covered



Photo courtesy of UNL Entomology

Figure 14. Oriental cockroach in sink drain.

and rely on the cockroaches either getting trapped by happenstance, or being attracted to the dark, covered space (**Figure 15**). Baited sticky traps may be impregnated with aggregation pheromones to catch more cockroaches. The brownbanded cockroach sex pheromone, supellapyrone, is occasionally used as a monitoring and management tool. In fact, use of the pheromone-enhanced trap catch 6-28 times compared to pheromone-less traps.¹⁰ Likewise, two sex pheromones from the American cockroach, periplanone A and B, also serve as useful monitoring tools.

Other lures, such as banana extract, apple oil, blueberry oil, orange oil, fish oil, peanut butter and bacon extract have also been shown to successfully attract roaches to traps. The combination of apple and blueberry oil extracts enhanced trap catch by 103% in field studies.¹¹ Lures can be applied as a few drops directly to the center of a glue trap and replaced as necessary.

Traps should be placed in known infestation areas based on your initial visual inspection. In addition to putting traps in these areas, traps should be placed in areas of “suspected infestation” i.e., places that cockroaches may be commonly found:

- Beside or behind the toilet
- Under the sink in the bathroom
- Beside the shower or bathtub
- Under the kitchen sink

- Behind, under or beside kitchen appliances
- In the back of each kitchen cabinet
- Behind or beside the washing machine
- Behind or beside the water heater

Depending on the level of infestation, traps can be replaced daily or weekly. With high infestations, traps may fill overnight and should be replaced. With lighter infestations, it may require several days or weeks to catch a significant number of cockroaches. You should continue to monitor until



Photo courtesy of Jody Green

Figure 15. Oriental cockroaches in a sticky trap.

population levels reach a specific threshold which is usually zero.

The number of cockroaches caught in each monitoring trap will help you determine the infestation level, as well as what IPM tools and action steps need to be taken. Comparing trap

9 Drago et al., “Evaluation of the Effectiveness of Three Sticky Traps to Monitor Four Species of Cockroaches (Hexapoda: Blattaria) with Simulated Use Tests.”

10 Liang et al., “Field and Laboratory Evaluation of Female Sex Pheromone for Detection, Monitoring, and Management of Brown Banded Cockroaches (Dictyoptera).”

11 Abbar and Wang, “Laboratory and Field Evaluations of Food-Based Attractants for Monitoring German Cockroaches.”

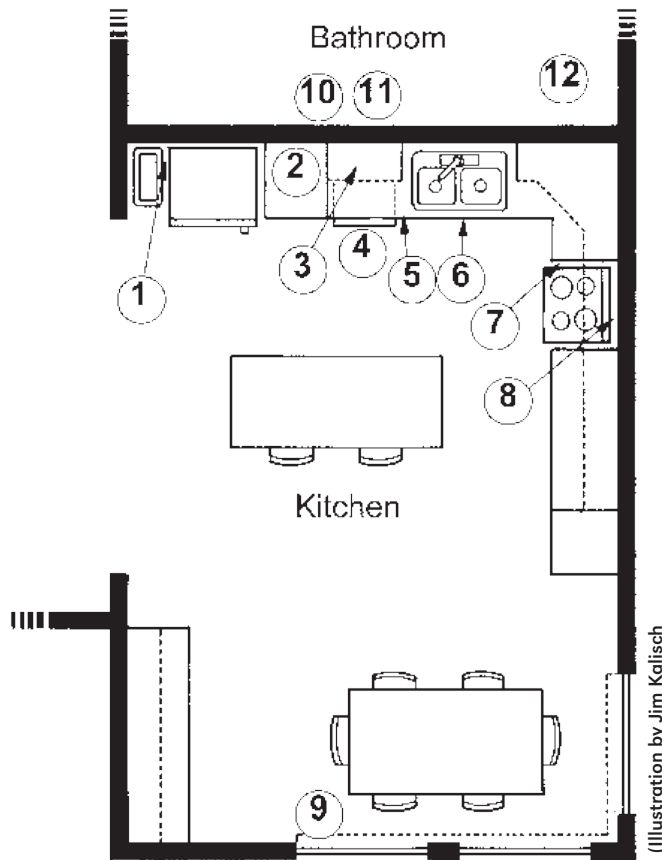


Figure 16. Where you should place traps for a hypothetical cockroach infestation.

catches will also give you an idea of where in the building the infestations are located. In low-income public housing, **assessment-based pest management (APM)** programs for the German cockroach contributed significantly to the decline

in cockroach infestations.¹² This APM approach utilized an assessment + bait protocol where each unit was evaluated using sticky traps for 24 hours. The amount of bait was then applied based on the number of cockroaches trapped. The same APM concept can also be applied to homes and buildings. Here, we outline the steps needed to evaluate a cockroach infestation:

1. Record the set and collection dates of sticky traps used for monitoring
2. Check each trap and record:
 - a. The average number of cockroaches per trap
 - b. The type/species of cockroaches
3. Divide the average number of cockroaches per trap by the number of nights the trap was out

This will give you **the average number of cockroaches per trap per night**. This number can provide you a rough estimate of the size of your cockroach population and infestation both before- and after-treatment (Table 3).

3.2: Prevent

Cockroaches are hardy animals: they can thrive on only crumbs and survive a couple of weeks without food and water. When it comes to management, cockroaches need three things to survive: **water, food and shelter**. Eliminating access to one or more of these can help you prevent cockroach infestations or end a current one. Once again, different cockroaches have slightly different requirements, which will be helpful knowledge in developing a management action plan.

Table 3. Relative numbers of the four domestic cockroaches captured per trap per night placed into low, moderate, high and very high categories.

Infestation	American	Brownbanded	German	Oriental
Low	0-1	0-3	0-5	0-1
Moderate	1-10	3-10	5-20	1-10
High	10-25	10-50	20-100	10-25
Very High	25+	50+	100+	25+

Based on the APM approach, the infestation level will influence how you design your action/treatment plan.

12 Miller and Smith, “Quantifying the Efficacy of an Assessment-Based Pest Management (APM) Program for German Cockroach (L.) (Blattodea).”

Cockroach Trap Worksheet (EXAMPLE)Cockroach species*: German cockroachDate trap installed: August 10, 2021Date trap removed: August 12, 2021Number of trap nights: 2

Trap No.	Location	Total cockroaches captured
1	Behind refrigerator, against back wall	20
2	On second pantry shelf, against back wall	21
3	Beside stove, against side wall	12
4	Beside shower in the bathroom, against wall	6
5	In far corner of basement	0
6	Behind toilet, against wall	5
7	Under water heater in the basement	1
8	Against wall, near floor drain in basement	1
9	Under the kitchen sink, against back wall	15
10	In lower cupboard, on wall next to dishwasher	12

Total # of cockroaches: 93Total # of cockroaches per trap: 9.3Total # of cockroaches per trap per night: 4.65**Notes:**

1. German cockroach infestation
2. Primarily located in kitchen and bathroom

Cockroach Trap Worksheet

Cockroach species*: _____

Date trap installed: _____

Date trap removed: _____

Number of trap nights: _____

Trap No.	Location	Total cockroaches captured
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Notes:

Total # of cockroaches: _____

Total # of cockroaches per trap: _____

Total # of cockroaches per trap per night: _____

* Contact your local Extension office for assistance in identifying different species of cockroaches.

So where did they come from? Cockroaches are easily transported from infested areas to new places. Cockroaches may have “come with the house or apartment” or you may have brought them with you from a different place. In fact, cockroaches can live in the little spaces of corrugated cardboard! Because it is fairly easy to unintentionally transport cockroaches during a move, there are several precautions you can take during to make it less likely:

- Thoroughly inspect items before packing
- Unpack moving boxes outdoors
- Use plastic tubs instead of corrugated cardboard to transport belongings

The key to preventing a new infestation in the home is **sanitation**. As mentioned, cockroaches need food and water to survive. Make sure to clean any messes and spills and store food in airtight containers. Another preventative tactic is exclusion. Oriental cockroaches can often crawl underneath doors or enter through cracks, and American cockroaches may enter buildings through the sewer system. Seal any cracks or potential openings cockroaches may use to gain entrance. A general guideline is **to seal or fill cracks that permit light through**.¹³ Screening in-use floor drains or closing them when they are no longer used, is also a good method of exclusion for species like the oriental cockroach. If they do somehow get inside, make the conditions as least-favorable as possible:

- Clean spills and crumbs.
- Store food in air-tight containers.
- Use a dehumidifier to reduce moisture.
- Practice good sanitation in the home.
- Seal cracks and crevices cockroaches may use to gain entrance.
- Remove garbage to an outdoor, sealed container.
- Clean behind and underneath kitchen appliances.
- Remove clutter.
- Keep exterior lights off.

Education is also a key component of preventing cockroach infestations. Urban pest management

is generally reactive instead of proactive. The percentage of individuals that seek professional aid in pest control is relatively low, so there is a high need for public education on pest identification, biology, monitoring and prevention.¹⁴ Education of residents in IPM programs for cockroaches makes the implementation and sustainability of control more efficient.¹⁵

If you still find yourself with a cockroach infestation, the next step in the IPM process is to create and initiate an action plan using a variety of tools, outlined in the next section.

3.3: Action

Because cockroaches live in close association with people and food products in homes, low-toxicity but high-efficacy management options are preferred to limit human pesticide exposure. Low-toxicity control measures blend well with an integrated pest management (IPM) approach that utilizes multiple tools, including the use of insecticides, to successfully manage pests like cockroaches. IPM tools for urban pest management include **cultural, physical, biological** and **chemical** techniques as detailed in **Table 4**.

Cultural Methods

Similar to the preventative methods outlined in the previous section, sanitation is important in long term management when used together in conjunction with other methods.

Physical/Mechanical Methods

Mechanical or physical management methods provide a low-risk option for control of cockroaches and should be used in tandem with cultural and chemical methods. Mechanical techniques like **trapping** are particularly effective for smaller cockroach infestations.

¹³ Eicher, “Environmentally Responsible Pest Management.”

¹⁴ Schoelitsz, Meerburg, and Takken, “Influence of the Public’s Perception, Attitudes, and Knowledge on the Implementation of Integrated Pest Management for Household Insect Pests.”

¹⁵ Dingha et al., “Integrated Pest Management of the German Cockroach (Blattodea).”

Another mechanical method for cockroach management is the use of **hot and cold temperatures**. Cockroaches are coldblooded organisms and cannot survive extreme temperatures on both ends of the spectrum. While domestic cockroaches are well adapted to a wide temperature range, they do not develop or reproduce below

45°F or above 115°F. This is particularly helpful in sensitive environments where pesticide usage isn't recommended, such as restaurants and food service establishments. Additionally, if a small, infested appliance is heat-proof, it can be placed in an oven for several hours at 150°F to kill any cockroaches. Freezing can also be used to kill cockroaches.

Table 4. Different IPM tools and how they can be applied to the management of urban cockroaches.

IPM tool	Definition	Examples for cockroach IPM
Cultural	The manipulation of the environment to discourage or reduce infestations	<ul style="list-style-type: none"> • Sanitation • Cleaning spills • Storing food in air-tight containers • Fixing water leaks • Removing harborage areas
Physical/ Mechanical	Method of reducing insect populations by killing, removing via non-chemical means and using barriers to prevent pest access	<ul style="list-style-type: none"> • Vacuuming cockroaches • Using sticky traps • Caulking potential entrance points
Biological	The use of beneficial organisms to manage pests	<ul style="list-style-type: none"> • Abamectin • Vertebrate mammals • Wasps
Chemical	Utilizing chemical pesticides to kill pests	<ul style="list-style-type: none"> • Toxic baits • Conventional insecticides • Biorational insecticides.

Sustainable pest management practices for cockroaches utilizes an integrated system. In multi-family housing or multi-unit apartments, building-wide IPM programs should be implemented. The above techniques should be used in combination with one another to achieve best results and prevent future infestations. Reliance on chemical insecticides alone presents issues, such as human and animal exposure, higher costs and the potential for resistance in the pest population to occur.

For small items that may be heat-sensitive, you can simply place them in sealable containers and then into the freezer overnight to kill the cockroaches. You can also use a CO₂ (carbon dioxide) gas canister to freeze cockroaches in small appliances by placing the appliance into an airtight container and injecting the gas.

Vacuuming is also a valuable resource to remove cockroaches. Make sure any vacuum used to collect cockroaches and their eggs has a HEPA air filter and the contents are disposed of in a sealed bag immediately and put into a freezer or an outdoor receptacle. Vacuuming itself does not kill cockroaches, so it must be used in combination with other IPM tactics and tools. It does, however, remove dead cockroaches, allergens and egg cases.

Commercial ultrasonic devices are available and are advertised as having repellent effects to many pest species including cockroaches. While these devices may sound enticing, research has shown that they do not, in fact, repel or kill cockroaches and are thus not recommended.

Biological methods

Biological control is a unique IPM tool that utilizes predators, parasites and pathogens to

successfully manage a pest. The use of biological control agents, such as vertebrate predators and parasitic wasps, for the urban pest management of cockroaches is not practical. However, the presence of some of these predators and parasitoids may actually indicate a larger problem. Ensign wasps, for example, parasitize cockroach egg cases. Likewise, the presence of predators like toads and spiders indicates that there is an abundant food supply, like cockroaches, in the area.

Other biological control agents are commercially available. The insecticide abamectin is a natural toxin produced by a soil-inhabiting fungus.

Abamectin has been formulated as a bait and dry flowable dust that acts as a stomach poison if ingested. *Metarhizium* and *Beauveria* are two other pathogenic fungi widely used as biocontrol agents of cockroaches. Additionally, the pathogen ***Periplaneta fuliginosa densovirus (PfDNV)***¹⁰ targets German, American and smokybrown cockroaches, and is commercially available as a cockroach bait gel.¹⁶

¹⁶ Pan and Zhang, "Advances in Biological Control of the German Cockroach, *Blattella Germanica* (L.)."

Chapter 4

Chemical Control / Insecticides

Stop!

Remember to always read the pesticide label directions before applying. Always wear proper personal protective equipment to limit your pesticide exposure.

Chemical control, or the use of pesticides, is one of the most common tools of IPM, especially when confronting cockroach infestations. Insecticides which are formulated to kill insects, utilize chemicals in the form of toxic baits, conventional insecticides and biorational insecticides. Insecticides are diverse in their risk factor, formulations and active ingredients. The application of insecticides can be done through a licensed applicator and pest management professional, but while less labor-intensive on the homeowner's part, it can be costly and less effective if proper sanitation is not maintained. Buying commercial products can sometimes be overwhelming due to the number of products available (**Figure 17**). In this chapter, we will go through each to outline your options for effective cockroach management.

Knowing the product's active ingredient and mode of action is key in both IPM and insecticide resistance management (IRM). The Insecticide Resistance Action Committee (IRAC) classifies active ingredients into classes based on their molecular makeup and mode of action. An insecticide's mode of action simply describes the molecular way in which a chemical insecticide kills an insect, usually by interrupting the normal



Figure 17. An example of the many insecticide products available at a retail store.

functions of things like enzymes. In this manual, we will simply refer to an active ingredient's insecticide class and mode of action main group. To see the specific primary site of action for each insecticide, visit <https://irac-online.org/>.

4.1: Low-Risk Insecticides

There are several lower-risk insecticides available commercially, including insect growth regulators, desiccants and “green” products. Low-risk tactics pose a reduced hazard to the applicator and/or the home inhabitants and pets, while at the same time, effectively controlling cockroaches.

Desiccants. Desiccants are effective because they literally dry out cockroaches that come into direct contact with the product. Desiccants kill cockroaches by destroying the waxy layer on the outside of their bodies that prevents moisture loss and should be used in places where the dust will not move around and cause irritation to mammals. Commercially, there are several types of desiccants available, including:

- Diatomaceous earth
- Silica aerogel

Insect growth regulators. Insect growth regulators (IGRs) alter the growth and development of cockroaches, and several are available for use as outlined in **Table 5**.

Table 5. Common IGRs available for cockroach control. *Hamilton et al. 2021

Active Ingredient	Trade Names	Formulation	Mode of Action
Hydroprene	Gentrol®	Concentrated liquid, aerosol	Causes infertility in adult cockroaches
Pyriproxyfen	Nyguard®, Archer®, Tekko®, Vendetta®, Pivot®	Concentrated liquid, aerosols, total-release foggers and gel baits	Exposed nymphs develop into infertile adults
Novaluron	Tekko®	Concentrated liquid	Prevents cockroaches from shedding their exoskeleton leading to nymphal mortality; interferes with egg case production*

Because IGRs do not directly kill cockroaches, they are often formulated with an insecticide which kills some of the cockroach adults and nymphs.

Green Products. Biorational pesticides are defined as any pesticide that has little risk to humans, animals or the environment, and are often considered “green” products. Plant oil extracts are some classic examples of this. Xanthine and oxypurinol, both naturally derived ingredients, are formulated into a pellet that is enclosed in a bait station for cockroaches. Several plant essential oils are also toxic to cockroaches upon contact:

- Clove oil
- Mint oil
- Neem tree seed oil
- Thyme oil
- Phenethyl propionate
- Rosemary oil

However, because direct contact with all cockroaches is unlikely, essential oils should be used with other IPM tools. Additionally, several oils have

exhibited a repellent affect against cockroaches. For example, Apiaceae plant essential oils and their constituents have a good potential as natural repellents against adult German cockroaches.¹⁷ While essential oils are promising for use as an insecticide, research is ongoing and there currently are no standard application rates or doses set.

Home remedies. Some people believe home remedies such as Osage orange, red pepper, spices and herbs, chalk, talcum powder, soapy water or baking powder will work against cockroaches. While these beliefs may have some merit, they are not based on scientific research and are therefore not recommended.

Baits. A bait formulation is an edible or attractive substance mixed with an active ingredient or toxicant. Management of cockroaches relies on cultural management practices and the application of insecticides, with insecticidal baits being the most efficient formulation. Baits fit well into urban IPM programs, both increasing control efficacy

17 Lee et al., “Repellent Activity of Apiaceae Plant Essential Oils and Their Constituents Against Adult German Cockroaches.”

18 Gondhalekar, Song, and Scharf, “Development of Strategies for Monitoring Indoxacarb and Gel Bait Susceptibility in the German Cockroach (Blattodea).”

and significantly reducing impacts on non-target organisms in insecticide-sensitive environments.¹⁸ Baiting is effective, targeted to cockroaches, applied at harborage areas and poses low risk to humans. Additionally, baits have also been shown to reduce cockroach-derived allergens.¹⁹

Placing smaller volumes of a bait, but with greater frequency, increases the odds cockroaches will encounter the bait than with larger, less frequent placements. Gel baits applied to a 2 x 2 inch of folded wax paper resembling a “taco” allows for easy bait distribution.²⁰ Baits should be placed in high infestation areas, in corners along walls, underneath or behind appliances and in other discrete locations.

The best active ingredients act slowly, which ensures enough bait will be eaten by the cockroach

to kill it, and secondary transfer of the bait (toxicant) occurs through cockroaches feeding on other cockroach feces, regurgitation or deceased bodies. Baits are sold as ready-to-use (RTU) bait stations, loose granules and gel formulations in syringe-style applicators. Baits are also diverse in their active ingredients as outlined in **Table 6**.

Table 6. Common baits and active ingredients available for cockroach control (2021).

Active Ingredient	Insecticide Group (sub-group)	Mode of Action Main Group	Resistance
Abamectin	Avermectin	Nerve and Muscle Action	Yes
Boric Acid	Borates		
Chlorpyrifos	Organophosphate	Nerve Action	Yes
Clothianidin	Neonicotinoid	Nerve Action	
Dinotefuran	Neonicotinoid	Nerve Action	
Emamectin Benzoate	Avermectins, Mibemyciens	Nerve and Muscle Action	
Fipronil	Phenylpyrazole	Nerve Action	Yes
Hydramethylnon	Hydramethylnon	Energy Metabolism	Yes
Imidacloprid	Neonicotinoid	Nerve Action	Yes
Indoxacarb	Oxadiazine	Nerve Action	
Novaluron	Benzoylureas	Growth Regulation	
Pyriproxyfen	IGR	Growth Regulation	

19 Lee et al., “Repellent Activity of Apiaceae Plant Essential Oils and Their Constituents Against Adult German Cockroaches.”

20 Gondhalekar, Song, and Scharf, “Development of Strategies for Monitoring Indoxacarb and Gel Bait Susceptibility in the German Cockroach (Blattodea).”

Utilizing baits alone can result in measurable improvements in the health of children.²¹ Baits deliver a higher insecticide dose, which may prevent the development of resistance. However, the German cockroach, for example, has exhibited resistance to several bait active ingredients including abamectin, chlorpyrifos, fipronil, hydramethylnon and imidacloprid. Additionally, behavioral resistance may occur where some cockroach populations avoid baits. German cockroaches have developed behavioral resistance to various phagostimulants of bait formulations, typically D-glucose and D-fructose, resulting in the failure to attract cockroaches to toxic baits.²² This can potentially be remedied by alternating between active ingredients and manufacturers over time. It is highly recommended to **rotate 3-4 bait active ingredients every 3 months**, with some falling into different insecticide classes and modes of action. Proactive monitoring in combination with baiting, is necessary. Be sure to check baits at least monthly to make sure they are not dried or empty.

4.2: Other Formulations & Active Ingredients

Other insecticides can come in a variety of formulations: dusts, ready-to-use (RTU) sprays, wettable powders, emulsifiable concentrates, aerosols and total-release aerosols/foggers. Different formulations are useful in different areas of a home or building, and each has its advantages and disadvantages. For example, dusts are convenient for hard-to-reach areas such as wall voids, and RTU sprays are easy to use and apply. While foggers are easy to use, they can be dangerous and are therefore **not recommended for control**. Research has suggested that foggers, even when properly used, do not cause a significant decline in cockroach numbers, but increase insecticide exposure risk to humans.²³

Insecticides can also control pests in specific

ways. For example, residual or persistent insecticides remain in active amounts sufficient to kill pests for an extended period of time. In contrast, contact insecticides must be applied directly to the insect while stomach poisons must be eaten by the insect.

Other formulations also have a wide variety of active ingredients to choose from and vary from their insecticidal class and mode of action (**Table 7**). Different classes of insecticides are based on the insecticide's chemistry and mode of action. Mode of action refers to the specific biochemical ways in which an insecticide causes death. For example, many insecticides block specific enzymes in the cockroach from being produced, eventually leading to death. The primary insecticide classes used in cockroach control today are:

- Avermectins
- Borates
- Insect Growth Regulators
- Neonicotinoids
- Oxadiazines
- Phenylpyrazoles
- Pyrethroids

Some insecticidal classes previously used for cockroach control are either **banned or no longer recommended**. These include chlorinated hydrocarbons (banned), carbamates and organophosphates such as Diazinon.

Pyrethroids are the most common residual insecticides used in cockroach control due to their fast knock-down activity against flying insects and low mammalian toxicity. Consequently, high levels of **resistance** to pyrethroids and other insecticides have been documented in many field populations of the German cockroach.²⁴ The German cockroach is one of the top 20 insecticide-resistant arthropods and has exhibited documented resistance to 43 active ingredients as of May, 2021.²⁵ The oriental cockroach has exhibited resistance to two active ingredients.

This reiterates the importance of rotating or using different modes of action of insecticides, as well as utilizing multiple IPM tools in your

21 Rabito et al., "A Single Intervention for Cockroach Control Reduces Cockroach Exposure and Asthma Morbidity in Children."

22 Silverman and Bieman, "Glucose Aversion in the German Cockroach, *Blattella Germanica*"; Wang, Scharf, and Bennett, "Behavioral and Physiological Resistance of the German Cockroach to Gel Baits (Blattodea)."

23 Devries et al., "Exposure Risks and Ineffectiveness of Total Release Foggers (TRFs) Used for Cockroach Control in Residential Settings."

24 Chai and Lee, "Insecticide Resistance Profiles and Synergism in Field Populations of the German Cockroach (Dictyoptera)."

25 "Arthropod Pesticide Resistance Database | Michigan State University."

Table 7. Common active ingredients available for cockroach control (2021).

Class	Mode of Action Main Group	Active Ingredient	Resistance
n/a	Non-specific mechanical disrupters	Diatomaceous Earth	
Organophosphates (1B)	Nerve action	Acephate	Yes
		Dichlorvos/DDVP	Yes
Phenylpyrazoles (2B)	Nerve action	Fipronil	Yes
Pyrethroids (3A)	Nerve action	Allethrin	Yes
		beta-Cyfluthrin	Yes
		Bifenthrin	Yes
		Cyfluthrin	Yes
		Deltamethrin	Yes
		Esfenvalerate	Yes
		Etofenprox	Yes
		Fenvalerate	Yes
		Imiprothrin	
		lambda-Cyhalothrin	Yes
		Permethrin	Yes
		Phenothrin	Yes
		Prallethrin	
		Resmethrin	Yes
		Tetramethrin	Yes
Pyrethrin	Yes		
Neonicotinoids (4A)	Nerve action	Dinotefuran	
		Clothianidin	
		Imidacloprid	Yes
Avermectin (6)	Nerve and muscle action	Abamectin	Yes
Juvenile hormone analogues (7A)	Growth regulation	Hydroprene	
		Methoprene	
Pyriproxyfen (7C)	Growth regulation	Pyriproxyfen	
Borates (8D)	Miscellaneous non-specific inhibitor	Sodium borate	
		Boric Acid	
Pyrroles (13)	Energy metabolism	Chlorfenapyr	
Benzoylureas (15)	Growth regulation	Novaluron	
Hydramethylnon (20A)	Energy metabolism	Hydramethylnon	Yes
Oxadiazines (22A)	Nerve action	Indoxacarb	

management program to prevent resistance from occurring. While the use of a single active ingredient can effectively manage pests if the beginning resistance levels in a population are low, rotation of treatments reduce selection pressure on the cockroach population, therefore delaying resistance.²⁶ **Some insecticide formulations will use more than one active ingredient** and will span multiple insecticide classes. This increases the insecticide effectiveness and decreases the likelihood of resistance occurring.

Resistance management relies completely on the education of the public and pesticide applicators.

For readily available resources on pest management, contact your local Extension office.

4.3: Application Methods

How insecticides are applied is also an important consideration. You should always read the pesticide label directions before applying any insecticide, because which insecticide formulation you choose influences where it can be applied. Here, we outline several common scenarios and the different formulations and application methods recommended for each (Table 8).

26 Fardisi et al., “Rapid Evolutionary Responses to Insecticide Resistance Management Interventions by the German Cockroach (*Blattella germanica* L.)”

Table 8. Formulations and application techniques for effective treatment of cockroach harborage.

Situation	Formulation	Application
Wooden floors	None	Not recommended
Wooden baseboards ^a	C & C ^b (aerosol, liquid WP or RTU)	Crack and crevice (aerosol, liquid WP, or RTU)
Vinyl baseboards ^a	C & C (aerosol, liquid WP or RTU)	Crack and crevice (aerosol, liquid WP, or RTU)
Carpets ^a	None	Not recommended
Electrical outlets, motors, compressors	Gel bait, dust, C & C aerosol ^c	Spot bait placements, dusting, crack and crevice aerosol treatment using plastic applicator
Painted drywall	None	Not recommended
Above false ceilings	Dust, tamper-proof bait stations	Dusting, bait station placements
Around or on pipes	C & C (aerosol or RTU), gel bait, dust	Crack and crevice (aerosol or RTU), spot bait placements, dusting
Wall voids	Dust, C & C aerosol	Dusting, crack and crevice aerosol application
Insulation, fiberglass	Dust	Dusting
Food storage ^d locations	C & C (aerosol, liquid EC, or RTU), gel bait or tamper-proof bait stations	Crack and crevice (aerosol, liquid EC, or RTU), spot bait placements and/or bait station placements
Appliances ^d	Dust, C & C aerosol, gel bait or tamper-proof bait stations	Dusting under and around, crack & crevice aerosol, or spot bait placements and/or bait station placements
Cabinets ^d	C & C (aerosol, liquid EC or RTU), gel bait or tamper-proof bait stations	Crack and crevice (aerosol, liquid EC or RTU), spot bait placements and/or bait station placements
Hot locations	C & C (aerosol, liquid EC, or RTU), gel bait or tamper-proof bait stations	Crack and crevice (aerosol, liquid EC or RTU), spot bait placements and/or bait station placements
Wet locations	Gel bait or tamper-proof bait stations	Spot bait placements and/or bait station placements
Greasy locations	C & C (aerosol, liquid WP or RTU), gel bait and/or tamper-proof bait stations	Crack and crevice (aerosol, liquid WP, or RTU), spot bait placements and/or bait station placements
Outdoors	Aerosol, liquid EC, or RTU	Band/perimeter and/or broadcast

a EC formulations can react with chemicals in wood stains, carpet dyes, and vinyl, resulting in reduced insecticide activity and damage to the surface.

b Crack and crevice

c Because these crack and crevice products contain no water or oil emulsifiers they are ideal for treating electric motors and switch boxes. The motor housings of refrigerators and freezers are an important and overlooked place where German cockroaches find an ideal habitat.

d Before application, remove all food and utensils and protect them from exposure to the insecticide.

Chapter 5

Evaluate Your Management Approach

The most common mistakes made in cockroach management programs in multifamily housing are:²⁷

- Relying too much on one approach or active ingredient;
- Underestimating the cockroach infestation;
- Missing portions of the cockroach population;
- Improper application of bait or;
- Not using enough bait.

Continuing to monitor is an essential step in the continuous IPM process. Monitoring for your pests after you've applied an IPM tool, like an insecticide, gives insight into the success of the methods and if alternative tools are necessary. Generally, if pest pressure remains the same or increases, another IPM tool should be used. Utilize monitoring techniques and continue to look for evidence of pests until the threshold is reached.

²⁷ Zha et al., "Pest Prevalence and Evaluation of Community-Wide Integrated Pest Management for Reducing Cockroach Infestations and Indoor Insecticide Residues"; Zha et al., "Spatial Distribution of German Cockroaches in a High-Rise Apartment Building During Building-Wide Integrated Pest Management."

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Cockroach Pests of the Northern United States



German Cockroach
(enlarged)



Brown-banded Cockroach
(enlarged)

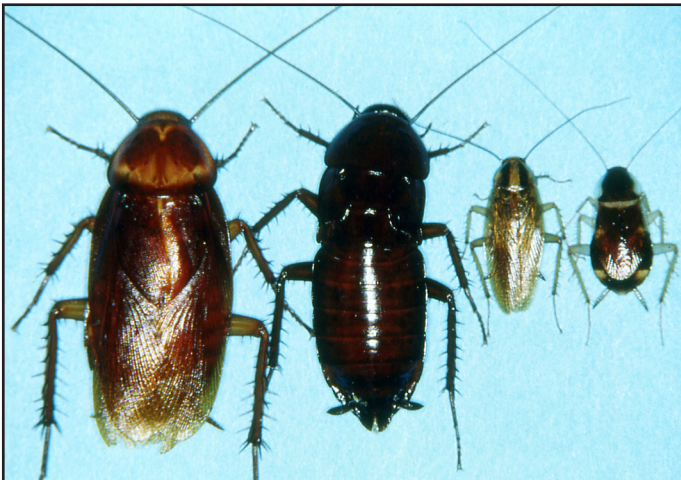
(Photos by Jim Kalisch, UNL Entomology)



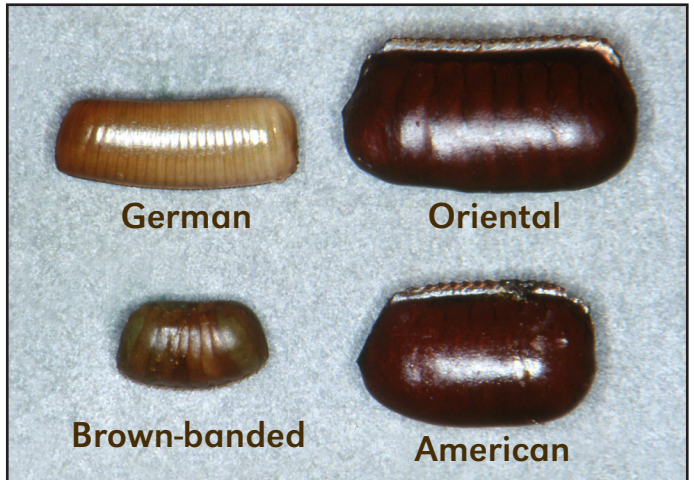
Oriental Cockroach
(slightly enlarged)



American Cockroach
(actual size)



Comparison of Cockroach Adults
(enlarged)



German Oriental
Brown-banded American

Comparison of Egg Cases
(enlarged)