

HOUSE-FREQUENTING INSECT PESTS

Pests that reside within the home may be associated with public-health problems. But usually these pests are homeowner responsibility issues rather than public-agency matters, with major exceptions being public housing, barracks and other similar types of government-operated institutions. A sound understanding of the **bionomics** of these arthropods is essential in order to respond correctly and provide proper advice to homeowners and public authorities. Four insect orders are included in this discussion: Hemiptera (bed bugs), Anoplura (sucking lice), Siphonaptera (fleas) and Blattaria (cockroaches). Bed bugs, lice and fleas are **ectoparasites** of humans. Other pests that invade homes but are less strictly associated with human activity (e.g., ants, spiders, flies, etc.) are treated in other chapters in this manual.

The body louse is involved in epidemics of louse-borne typhus, trench fever and relapsing fever. Other human-infesting lice do not transmit disease organisms. Bed bugs have not been incriminated in the transmission of any disease agents as a vector, but about 25 different disease organisms have been found in bed bugs. Some of these organisms have survived for long periods of time in these insects. Bed bugs may cause nervous disorders in sensitive people and contribute to the ill health of both children and adults. Fleas transmit the causative agents of such diseases as plague, typhus and tularemia to humans and can serve as intermediate **hosts** for dog, cat and rodent tapeworms, which may occasionally infest humans, particularly young children. Cockroaches have been found to cause asthma and associated allergies in humans.

I. BED BUGS

The wingless bed bug, *Cimex lectularius*, is a notable bloodsucking **parasite** of humans so well-adapted to humans that its bite is nearly painless. The bed bug (Figure 4.1) is in the insect order Hemiptera and is a true bug. For all other orders the use of the term “bug” is incorrect scientific terminology, although it is often accepted as part of a common name when combined with another word. For example, ladybugs are not true bugs but are actually beetles. True bugs will have the term “bug” as a separate word, as in “southern green stink bug.” Bed bugs, like other **hemipterans**, exhibit gradual **metamorphosis**.

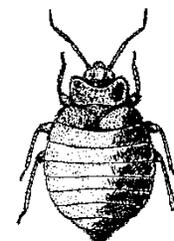


Figure 4.1
Bed bug

Insecticidal control has been so effective that bed bugs, once a major pest in the U.S., are now of minor importance. However, the increasing use of baits, which do not control bed bugs, in place of residual insecticidal sprays to control cockroaches and ants, combined with the ever-increasing numbers of visitors to and from other countries, is resulting in more frequent reports of bed bug infestations at many hotels. These infestations then spread to homes and other buildings in luggage or furniture.

Developmental Stages

Eggs. Bed bugs lay one to five eggs a day over a period of two to 10 months, producing about 200. They deposit the 1 mm white eggs intermittently each day in protected places near their hosts' sleeping quarters, cemented to bedding or in cracks. The eggs hatch in one or two weeks, depending on temperature.

Nymphs. Tiny and colorless at first, **nymphs** undergo five molts, each resembling the adult form and each requiring a blood meal. Each blood meal takes about three to 10 minutes, during which the nymphs inject saliva containing an anticoagulant. The nymphal period can last for several weeks under favorable conditions to as long as a year when temperatures and host availability are low.

Adults. Adults are 1/5 inch long, 1/6 inch wide and reddish-brown in color. Their flattened oval bodies are well-adapted for hiding in narrow crevices. The head bears a pair of four-segmented antennae and **piercing-sucking** mouthparts that fold to lie between the first pair of legs. The wings are represented by pads. The body may become greatly enlarged and blood-red in color during a blood meal but turns a dirty brown subsequently. Females can live nearly a year without food and can endure freezing temperatures for considerable time.

Bionomics

Bed bugs are found on the bed clothes and possessions of infested individuals. They commonly occur in such places as seams of mattresses, inside mattress coils, cracks in bedsteads, bedside furniture, dressers, wallboards, wood paneling, door and window frames, behind pictures, under loose wallpaper and in rooms near host sleeping areas. A heavily infested house has a distinctive odor. Some people are very sensitive to bed bug bites while others are hardly aware of them. Immediately after feeding, bed bugs defecate the semisolid, sticky remains of the last meal, a good clue to their presence. Humans are the preferred host, but bed bugs will feed readily on poultry, mice, rats, some song birds and other animals.

Detection and Control

Look for bed bugs by inspecting their harborage, usually in and around bedrooms or sleeping areas. Camping and sleeping equipment, outdoor animal sheds and coops are alternative sources of infestation.

Habitat alteration to exclude alternate hosts such as rodents, birds, etc., is important in vermin-proofing living quarters. Keep woodpiles, shrubs and weeds away from the foundation of the dwelling. Eliminate garbage. Caulk and screen routes of entry. Store mattresses in protected areas, unfolded to prevent rodent nesting. Allow light to enter crawlspaces, cabinets, etc., to discourage use of such **harborage**.

To control bed bugs, caulk or otherwise repair all cracks and spaces behind baseboards and other areas of the house. Treat infested areas with liquid or dust insecticides registered for this purpose. Treat baseboard crevices, closets, wood paneling and other places that harbor bed bugs. Avoid spray runoff if applying liquid insecticides onto surfaces and into cracks. Residual applications reduce the need for repeat applications. A single application is usually sufficient in a home, but multidwelling structures and hotels require frequent inspections and perhaps repeated applications. If the infestation is localized in an apartment building or hotel, treat all units connected to the infested area.

Thoroughly treat the frame, slats and springs of beds. To treat the mattress, apply a light mist to seams, tufts and folds but not to the entire mattress. Follow label directions, or allow four hours if not specified on the label, for the spray to dry before covering the mattress with a sheet. Ventilate the room while spraying and during drying. Treat infested upholstered furniture in the same way as mattresses by lightly spraying or dusting only the edges and seams of cushions, furniture joints and the inside (hidden) framework. Avoid treating sit-on or arm-rest areas. Do not use treated furniture or bedding until it is thoroughly dry; better still, do not use it for 72 hours after treating with an insecticide. Before allowing children on treated furniture, vacuum it thoroughly to remove loose and excessive amounts of chemical. Space treatments and fogs are not effective. Do not treat the bedding (mattresses and frames) of infants or the infirm, but replace with uninfested items.

Two other species of bed bugs, called bat bugs, are usually found in bat colonies. They may wander into living areas just below attics. To control these pests, locate the infested bat-nesting sites, dust after the bats and detritus have been removed, then seal host entry points to prevent reinfestation.

II. LICE

Lice are intimately associated with humans. Louse infestations occur today in the U.S. despite great efforts to maintain high standards of public hygiene. Public-health agencies are often called upon if infestations include or expose large groups of people, particularly those in public institutions such as schools, jails, hospitals or homes for the elderly. The three sucking lice that infest humans are the head louse, *Pediculus capitis*; the body louse, *Pediculus humanus*; and the crab louse, *Phthirus pubis*. The head louse and body louse are nearly indistinguishable unless observed under a dissecting microscope, and even then it might require the aid of an expert to correctly identify a specimen to species. Lice complete their entire life cycle on the human host or within the host's clothing. Lice undergo gradual metamorphosis.

Developmental Stages

Eggs. Eggs can appear white, gray, tan, brown or even black and are about 0.8 mm by 0.3 mm. They have a cap at one end to admit air during development of the embryo and to facilitate escape of the young insect. The eggs of the head louse and the crab louse (Figure 4.2) are attached to a single human hair with a cementlike substance. Body louse eggs (Figure 4.3) are cemented to clothing fibers. Eggs are incubated by body heat and hatch in about a week to ten days. Eggs can survive and complete development off-host. Although the hatching rate is far below normal, eggs can hatch in up to nine days off-host at room temperature.

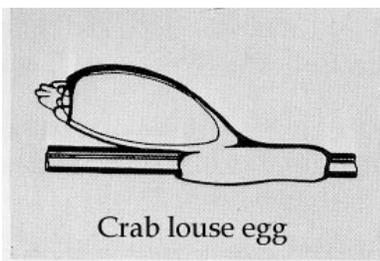


Figure 4.2

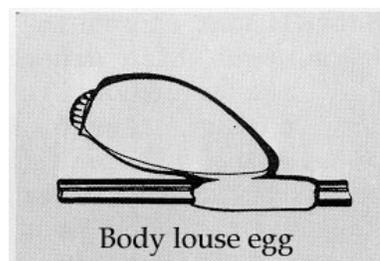


Figure 4.3

Nymphs. After emerging from the eggs, the louse nymphs molt three times before becoming sexually mature adults. Crab lice and head lice will mature in seven to 12 days. The nymphal stages of the body louse require eight to nine days when remaining in contact with the human body but may require two to four weeks when the clothing is removed at night. If the clothes are not worn for several days, all of the lice will usually die. All three **species** can survive up to 48 hours off-host without a blood meal; however, the higher the temperature, the quicker they will die.

Adults. Adult body or head lice differ little from nymphs except in size and sexual maturity. Adult body and head lice range from 1.5 mm to 3 mm in length. The mouth is encircled by six pairs of hooks that the louse uses to attach to the skin during feeding. There is also a soft, retractable, sucking mouth with piercing **stylets** to open the wound and provide a salivary duct. When ready to feed, the louse anchors its mouth to the skin, stabs an opening through the skin, pours saliva into the wound and pumps blood from the injury into the digestive system by means of the pharyngeal pump.

The three thoracic segments each bear a pair of strong, five-segmented legs that terminate in a hooklike claw which enables the louse to maintain its hold on hairs and fibers. Mating occurs frequently and at any time in the adult's life, from the first 10 hours to senescence. Eggs are laid 24 to 48 hours later, depending upon temperature conditions. Body lice may deposit nine or 10 eggs per day, totaling 270 to

300 eggs in a lifetime. Head lice are less prolific, depositing about four eggs per day for a total of about 90 in a lifetime.

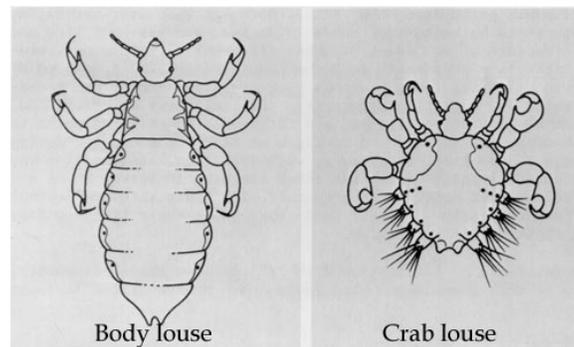


Figure 4.4

Bionomics

Head lice are confined to the head hair and scalp where the adult and immature lice, particularly the eggs, are found fastened to the hairs. Body lice are found on hairy parts of the body below the neck, with adult and immature lice and eggs frequently on clothing, especially along the seams of the inner surfaces. Crab lice are found in the pubic and anal regions and occasionally in the armpits, on hairy areas of the chest, and on eyebrows and eyelashes.

Head lice affect an estimated 12 million people annually in the U.S. The vast majority of these are school-aged children, particularly children ages 5 to 10. Head lice infect children of all backgrounds regardless of care given to personal hygiene. Head lice are primarily transmitted through direct head-to-head contact, but objects such as combs and hats also may contribute to transmission. Recent research has suggested head lice have become resistant to some of the more popular treatments available over-the-counter. This condition may be contributing to the increased number of head lice cases.

Adult and immature head lice are seen less frequently than the eggs, commonly called nits, which are fastened to the hairs, particularly those behind the ears. Public-health workers should be aware that foreign material in the hair and hair casts (inner hair root sheaths that have slid along the hair shaft) have been mistaken for eggs. A number of infestations have been reported in which solidified globules of hair spray were confused with eggs. In other instances, students have been sent home because of small whitish objects attached to their hair. An amorphous cellular mass was found in some cases and hair follicle mites (*Demodex* spp.) in others. Seen through a microscope, a nit is easily distinguished from other objects by distinct characteristics: the ring at the base of the egg by which it is fastened securely to the hair; the egg itself, frequently with an embryo visible inside; and the cap (operculum), which has definite pores. The female louse **oviposits** eggs on the hair shafts very near the scalp. As the hair grows, the egg moves further away from the scalp. Eggs that are more than 2.5 cm from the scalp are probably old eggs that did not complete development or empty egg shells.

Infestations of body lice are generally associated with people living crowded together and having limited facilities for regular bathing and laundering. They are most common during times of stress, such as in evacuation centers, labor camps and institutions, and are commonly associated with tramps and migrants as “hobo's disease.” Severe infestations lead to scratching, secondary infections and the classic signs of pediculosis — scarred, hardened or pigmented skin. After the widespread use of DDT following World War II, there were relatively few reports of body lice in the U.S. Body lice are still uncommon except among populations of homeless people or those in similar situations.

Crab lice are approximately 1 mm to 2 mm in length as adults and are relatively uncommon in the human population. The last two pairs of legs have hooked mitts that resemble claws. They usually are transmitted during sexual intercourse.

Most sucking lice spend their entire life as **ectoparasites** on mammals. The body louse is a conspicuous and important exception because it rests on clothing except when feeding. Sucking lice occur only on mammals, not on birds, reptiles or amphibians. Each species of louse generally feeds upon only one **species** of host animal, one **genus** or, more rarely, one group of mammals. In general, closely related groups of mammals appear to be infested by closely related species of lice. The three species of lice that infest humans are **host** specific. They exist only on humans. Lice of other animals normally do not infest humans.

Human lice depend upon human blood for sustenance. They suck blood for long periods of time but do not ordinarily become fully engorged. During feeding, dark red feces may be deposited on the skin. Head louse adults and nymphs are most prevalent on the back of the neck and behind the ears. They are not known to infest eyebrows or eyelashes, as does the crab louse. The typical head louse infestation consists of fewer than a dozen adult lice. While as many as 1,000 body lice have been removed from the undergarments of one person, infestation of fewer than 10 lice per person is more typical. Most of the lice are on the inner surface of the clothing, next to the skin.

Detection and Control

Public institutions, such as hospitals, jails and nursing homes, sometimes find incoming people infested with lice. When the incidence is high, it may be necessary to use experienced inspectors or public-health nurses to inspect all people entering such institutions and to treat infested people. Infestation should be handled as a medical problem, and considerable effort must be made to avoid exposure of patients to ridicule. When outbreaks occur in schools, children must be examined daily upon returning home, otherwise they are likely to become reinfested and the condition may spread to classmates. In many instances other family members and close associates may require treatment. Lice infestations are a medical problem. Pesticide applicators, even those in public health, should not make recommendations concerning medications for control.

Head lice. Several over-the-counter and prescription preparations are used to eliminate head louse infestations. Newer over-the-counter products available do not contain traditional pesticides but possess botanical ingredients or enzyme derivatives. The prescription preparations are usually effective with a single application, whereas the others may need to be used twice — first to kill live lice, and then six to 10 days later to kill those that emerge from nits. Both types are applied to wet hair and then shampooed out after a sufficient exposure period. Infested family members should be treated at the same time, and bedding, hairbrushes, knit caps, etc., should be washed. Rugs and carpets should be vacuumed and cleaned or simply quarantined for 10 days after vacuuming.

Body lice. Hatch is greatly reduced or completely prevented by exposure to temperatures above 100EF or below 75EF. Thus, the body louse is readily suppressed when the same garments are worn intermittently. When the same clothing is worn for several weeks or months, it may become heavily infested with body lice. Conversely, if clothing is stored for a month, even without treatment, all eggs will hatch or die, and any young that hatch will die. Body louse epidemics on humans are controlled by emergency applications of pesticides (usually in the form of shampoos), but control is maintained by cleaning and washing clothes. Some pesticides are labeled for spraying but are of little use. Infested individuals should bathe to detach and kill moving lice on the body. Clothing and bedding should be

washed with hot water and detergent and then dried in a clothes dryer set on “high” to kill the lice. Disinfectants and detergents can be used on bed frames, furniture, ambulances and hospital equipment.

Crab lice. Commercial preparations are available for crab louse treatment, many of which are the same as for head or body lice. Bedding and underwear should be washed, toilets disinfected and carpets vacuumed; there is no need to make insecticidal applications to surrounding areas.

III. FLEAS

Fleas (Figure 4.5) are members of the order Siphonaptera, named for their mouthparts and wingless condition. Worldwide, more than 2,200 species of fleas parasitize mammals and birds. Fortunately, humans encounter only a few of these species, the most common being the cat flea (*Ctenocephalides felis*), dog flea (*C. canis*), human flea (*Pulex irritans*) and oriental rat flea (*Xenopsylla cheopis*). Fleas are medically important because of their irritating bites, abundance and ability to transmit diseases. The oriental rat flea is the primary vector of **bubonic plague** and murine typhus. Dog and cat fleas are intermediate **hosts** of tapeworms that can infest humans if accidentally ingested.

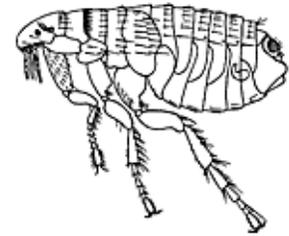


Figure 4.5
Flea

People have differing reactions to flea bites, in which three **stylets** are used to penetrate the skin and suck blood. Some are oblivious to the bites, unattractive to fleas or both. Others seem to be highly attractive to fleas. In a flea-infested household, one or two individuals may show severe irritation from the bites, whereas others may not even realize fleas are present. Household fleas prefer the blood of pets. Thus, people may coexist with the pet and the pet’s flea population while being bitten only occasionally. When the pet is removed from the environment, such as during a family vacation, a large population of hungry adult fleas may accumulate. When hungry, adult fleas tend to lose their one-track desire for the pet’s blood and will then attack any warm-blooded animal, humans included.

Fleas most often bite people on the legs and ankles; characteristically, two or three bites in a row. A small, red spot with a light-colored center appears where the mouthparts entered the skin. Irritation, itching and rash are caused by salivary secretions that the flea injects during feeding. The typical human reaction to a flea bite is a small, hard, red, slightly raised, itching spot. Usually there is no swelling. Some bleeding can occur, particularly if the bite is scratched. Cats and dogs scratch and bite themselves constantly when heavily infested. Their coats become soiled and roughened, and their skin is irritated as a result of a flea infestation.

Developmental Stages

Under normal conditions, the entire life cycle of cat fleas may be completed in as few as 20 to 35 days. The cycle is influenced by temperature and moisture conditions, with 85EF and 85 percent relative humidity being near ideal. Under less favorable conditions, complete development may require months or even a year. Flea production may take place indoors year-round, while outdoor production is limited to warm weather months. Sustained temperatures below 55EF inhibit larval development. There are four stages in the life cycle of fleas: egg, **larva**, **pupa** and **adult**.

Eggs. Flea eggs are smooth, oval, whitish, about 1/50 inch long and visible to the naked eye. The eggs hatch in two to 14 days, depending on environmental conditions.

Larvae. Newly hatched larvae are wormlike and whitish; when mature, they can be up to 1/8 inch long. Larvae lack legs and eyes and have chewing mouthparts. Fleas pass through three larval stages and

are fully developed within eight to 24 days. The larval stage, however, can be prolonged to more than six months under adverse conditions.

Pupae. Before entering the inactive pupal stage, the fully grown larvae spin silk cocoons. They incorporate debris particles that camouflage the cocoons in their natural surroundings. Each larva then pupates within its cocoon. The pupa, initially creamy white, gradually darkens to a brownish color. The pupal state typically lasts from five to seven days but may be prolonged up to a year by unfavorable conditions.

Adults. Adult fleas are small, wingless insects, approximately 1/16 to 1/8 inch long. They are dark reddish-brown to black, with the mouthparts of both males and females adapted for puncturing animal skin and sucking blood. The third pair of legs is modified for jumping. Some species breed continuously, needing only a month or so to complete a generation, whereas others have but one generation per year.

Bionomics

Most flea species infest smaller animals, such as rats, mice, rabbits, moles and bats, but some are **parasites** of larger animals and birds. Most are specific in **host** preference. They are very sensitive to temperature and humidity. The adult flea, even while still in the cocoon, recognizes the presence of a potential host by the host's body heat and odor and by vibrations. This is one reason fleas often attack people returning home after vacation or when new occupants move into quarters formerly occupied by people with pets. Eggs are usually deposited onto the skin or hair of the host pet, from which they drop onto the pet's bedding, carpet, rugs, mats, etc. Thus, the greatest concentration of eggs is where the pet spends the most time. The fertilized adult female flea lays two to 14 eggs after each blood meal, producing as many as 800 eggs in her lifetime.

The slender, whitish, sparsely bristled, legless larvae are often found in floor cracks, rugs, carpets and animal bedding. They can move quite readily using their body bristles for traction. They are scavengers, feeding on a wide variety of organic debris including pet dander, but their main food is the dried blood defecated by the adult fleas. Flea larvae prefer a dark, moist environment.

Adults may remain in the cocoons for up to five months, depending on the availability of a host and environmental conditions. Their bodies are well-adapted to their particular way of life. That is, the body is thin (laterally compressed) and covered with a series of backwardly directed spines so that adults can move rapidly through the hair or feathers on the host. Their powerful legs permit them to jump as far as 7 to 8 inches vertically and 14 to 16 inches horizontally. This ability may give the false impression that fleas can fly.

Cat fleas and dog fleas. These pests exhibit similar behavior, habitat preferences and life cycle characteristics. The cat flea is the most prevalent species in the U.S. and is commonly associated with cats, dogs and humans. The dog flea is a major pest throughout Europe, preferring dogs and other canids, but is infrequently encountered in the U.S. These fleas prefer places where dust and organic matter accumulate and are commonly found inside and outside, under buildings and in yards. They remain on the body of the host, feeding frequently, whereas rodent fleas stay in the host's bedding, feeding only when the host is present in the daytime. The digested host blood is excreted as a corkscrew-shaped string of black, nearly dried blood that breaks up into pepperlike specks. They inject irritating saliva that prevents the host blood from coagulating and often initiates an allergic reaction in the form of dermatitis, hair loss, etc.

Oriental rat flea. This important vector is found as far north as New Hampshire, Minnesota and Washington, where it is abundant in the summer but less so in colder months. *Xenopsylla vexabilis*, the Hawaiian rat flea, is a close relative with similar bionomics. Fleas become infected after feeding on a

plague-infected animal. The bacteria, *Yersinia pestis*, multiply in the flea's crop and stomach, where they might cause an obstruction. Such fleas are said to be "blocked." When the flea attempts to feed again, blood cannot pass beyond the blockage and becomes contaminated with plague bacilli. The contaminated blood is then regurgitated back into the host. This flea is the most important vector of plague because of this tendency to regurgitate plague organisms, its ability to feed on both humans and rodents, and its great abundance near human habitation.

Human flea. This flea is important because of its ability to cause dermatitis and allergic reactions by its bites. It attacks many other hosts, including dogs, ground squirrels and prairie dogs. Among these hosts it is responsible for transmission of tapeworms. In Hawaii the false human flea, *Pulex simulans*, co-exists with the human flea and feeds primarily on dogs.

Sticktight flea. The sticktight flea (*Echidnophaga gallinacea*) attaches firmly to its host, often causing ulcers on the head and neck. The female flea remains attached for the rest of her life, sucking blood and laying eggs that fall off the host and collect in the environment. Larvae hatch and go through a life cycle similar to that of the cat flea. Although the main host is poultry, this flea attacks cats, dogs and many other animals, including humans.

Detection and Control

In addition to families and pets, several species of urban and rural wildlife support flea infestations, including chipmunks, ground squirrels, opossums, raccoons, coyotes and prairie dogs. These sources might need to be considered when control efforts seem to be only partially successful. Pets are always aware of the location of wildlife habitats in their own backyard. As soon as they are released they run to these places to investigate. This behavior facilitates flea reinfestation of clean pets.

Close inspection of indoor and outdoor pet areas may be required to detect even high flea populations. Typically, fleas need warm and relatively humid conditions to thrive outdoors. Favored pet feeding, sleeping or resting areas, such as pet beds or blankets, kennels, doghouses, under bushes, in crawlspaces, etc., are natural flea **harborages**.

Formal surveys are essential in managing flea-borne disease, usually focusing on sampling rodent and other small animal populations to determine the relative abundance of fleas in an area. To do this, rodents are trapped with snap traps, and the captured animals are placed in plastic bags (within eight hours) to contain the **ectoparasites**. Larger animals are trapped with live traps from which the animals are removed, anesthetized and then combed with a fine-toothed comb over an enamel pan to collect specimens. Protective clothing is worn during this process to prevent escaping fleas from biting personnel. The surveys, made before and after control operations, can be used to measure effectiveness and duration of management techniques.

It is essential to manage fleas before controlling their host. If the hosts are killed first, the fleas abandon them and seek other hosts, complicating the operation and potentially exposing alternate hosts to disease organisms.

Habitat alteration. Exclusion procedures to prevent access of pets and infested animals to crawlspaces and areas under porches and buildings, as well as trapping and relocating wildlife, may be required to eliminate difficult infestations. Wall voids, subfloors and spaces, and under product shelves serve as rodent entryways and lead to contact with humans.

Burrow treatments. Insecticidal dusts can be applied in a manner that leaves a light film covering the entire treated surface. Apply the dusts with a duster wherever target rodent burrows are found, such as in prairie dog colonies, holes in floors and walls, and other enclosed areas that may serve as harborages.

Urban pesticide application. To successfully control fleas, treat inside infested structures, outside at sites of flea concentrations and the infested animal(s). Treating only one or two of the three almost always leads to a reinfestation because fleas that remain will find the animal and then are further distributed to other areas.

Before applying insecticide indoors for flea control, vacuum the premises thoroughly, especially pet resting areas, to remove as many developing fleas as possible. Vacuuming carpets will not completely destroy larval populations because the spiny larvae wrap themselves tightly around carpet fibers. However, vacuum-cleaner vibrations will cause adult fleas in cocoons to emerge immediately, allowing them to be sucked into the vacuum. Vigorously vacuum the entire structure, especially those areas most frequented by the infested animals. Vacuum carpets, particularly around legs of furniture that pets rub against. Also vacuum cracks and crevices along baseboards, upholstered furniture if the pets are allowed on such furniture pieces and even under beds if the pets are allowed on the beds. As soon as the vacuuming is completed, place the vacuum bag in the trash in a sealed plastic bag. Otherwise, the vacuum bag may become a source of reinfestation of the house.

A fine insecticide mist can be sprayed on floors, furniture, cracks and crevices using insecticides approved for adult fleas. An insect growth regulator (IGR, usually with fairly long residual activity) will help prevent flea larvae from maturing and can be incorporated into the spray mixture. These products are odorless, nonstaining and relatively nontoxic. It is usually necessary to make a second application after about 10 to 14 days because flea pupae not affected by the first spray will then be adults. While total release aerosols are available for quick knockdown of adult fleas, this type of application alone is rarely successful because it does not affect the other stages of the flea.

During warm weather thoroughly treat infested outdoor premises such as dog houses, garages, porches, dog runs, fence lines and the loafing areas of the yard. Prevent pets and all other animals from getting under the house. Treat all areas frequented by pets. As with indoor situations, a second application may be necessary outdoors. In cold weather, fleas may remain in the pupal stage for long periods and thus escape the effects of a treatment that eliminates larvae and adults.

Treatment of pets at the same time as the structure is important because the pet may be the primary source of flea infestation. Veterinarians can supply on-animal flea-control products that provide several weeks of suppression either by a few drops on the back of the animal's neck or as a spray with long-term residual activity that also kills all the fleas on the animal within a few hours. Also available through a veterinarian are IGR formulations that can be administered to a pet once a month in the form of a tablet (dogs) or liquid formulation in food (cats). When initiated early in the season this can prevent a flea problem from developing because the IGR is incorporated into the pet's blood and prevents female fleas from producing viable young. Specific formulations can be applied topically once a month to dogs and cats over six weeks of age that kill adult fleas and prevent egg hatch. These products provide rapid knockdown of fleas on pets, have long-term residual activity and are relatively convenient to use. While roaming pets may still encounter fleas, the fleas will be unable to survive and infest the home.

Flea-control products containing rapidly degraded insecticides, although effective, do not provide residual effect. Other formulations labeled for use on pets include shampoos, aerosols, dips, dusts and sprays that usually provide short-term control.

Treatment of puppies and kittens may be hazardous. Some products provide long-lasting control, but can be lethal to cats and puppies. Read the label carefully. Attention should be directed to their mothers and infested areas after they have been moved to clean bedding.

IV. COCKROACHES

Cockroaches have plagued mankind since the beginning of recorded history. Not only can cockroaches live with us, they live around us in both urban and rural areas. Even cockroaches that do not necessarily thrive under the same living conditions as house-dwelling species will wander in from the outdoors through convenient openings in walls, windows and doors.

Small populations of house-dwelling cockroaches may not be obvious, as they prefer to hide in cracks and crevices during the day and forage for food and water at night. Cockroach numbers can easily grow, however, creating large populations in relatively short periods of time. Even small cockroach populations can create problems for humans. The problems that cockroaches cause may be classified as either aesthetic or health-related. Aesthetically, cockroaches produce objectionable odors, leave behind their cast skins and feces, and result in disgust and/or embarrassment for homeowners.

Health-related problems caused by cockroaches include asthma and allergies, especially for children living in inner cities where high cockroach populations are **endemic** and up to 35,000 cockroaches might infest a single apartment. At such density, cockroach feces and body parts are abundantly present as allergens. Cockroaches are also potential mechanical vectors of disease and have been shown to be capable of mechanically harboring the **pathogens** that cause leprosy, urinary tract infections, conjunctivitis, pneumonia, wound infections and food poisoning. Pathogens may be spread by oral or fecal contact, or by cockroaches walking across surfaces or through foodstuffs. Given the opportunity, cockroaches will also feed on human tissue, secretions and hair, resulting in direct contact with humans and possible direct transmission of pathogens.

Developmental Stages

Eggs. Female cockroaches of all **species** produce egg capsules (oothecae) that may be carried within her body or extrude from the tip of the abdomen. Depending on the species of cockroach, egg capsules may be glued to surfaces such as walls, or inside furniture, or they may be held until immediately before hatch. Egg capsules are usually 1 mm to 1.5 mm long and may contain 12 to 48 eggs. Depending on species, the egg case may take several days or weeks to hatch.

Nymphs. Cockroach nymphs undergo gradual **metamorphosis** and may go through eight to 13 **molts** before they become adults. Nymphs are usually very similar in appearance to adults, except that they do not have fully formed wings. The time required from hatch until the final adult molt may range from just under two months to as long as two years, depending on environmental conditions and cockroach species.

Adults. Adults of many species of cockroaches possess wings, although not all of these are actually able to fly. The longevity of adult cockroaches depends on both the species of cockroach and various environmental conditions. As a general rule, the larger the cockroach species, the more long-lived it is. For example, adults of the American cockroach, a large **peridomestic** species, may live up to a

year or more, whereas smaller species such as German or Asian cockroaches have an average adult life span of approximately six months.

Bionomics

Most cockroach species display negative phototaxis, moving away from light sources. They prefer to forage for food, water and mates during the hours that begin a few minutes after sunset and end shortly before dawn. Generally, female cockroaches with egg cases and small nymphs tend to stay within hidden **harborage** areas. Males and large nymphs are usually the most active cockroaches and are therefore seen more often by humans. Their ability to adapt to a variety of conditions and to thrive in commerce leads to infestation by being transported in grocery sacks, boxes and a wide variety of carriers.

Cockroaches have evolved into a laterally compressed body shape that allows them to fit into relatively small cracks and crevices, and they have legs that are well-adapted for running. Cockroaches will react to slight puffs of air by darting forward, running away from the air source. This defensive mechanism aids in protecting cockroaches from predators.

Cockroaches are omnivorous and can subsist on a wide variety of possibly unlikely food sources. It has been documented that cockroaches eat garbage, fresh or decaying food and food scraps, hair, leather, skin, dead animals, dry plant materials and some paper products. However, cockroaches can go for long periods of time without either food or water. Their ability to subsist on a minimum amount of resources, combined with their great mobility and tremendous fecundity, greatly enhances their survival ability in both urban and rural environments.

German cockroach (*Blattella germanica*). Approximately 80 percent of a German cockroach population consists of nymphs. The remaining 20 percent is approximately evenly divided into adult males and females. Of the females, a large proportion of them will be **gravid** and will be secluded in harborage areas. Nymphs of all stages are black in color with a light brown band around the outer edge, as well as down the middle of the back. The length and breadth of the band will vary in size, depending on the age of the nymph. Adults are approximately 1.6 cm in length. Both males and females range in color from light to dark brown, with the female somewhat darker than the male. Both males and females possess wings and have two black lines extending down the **pronotum**, or upper back area (Figure 4.6).



Figure 4.6.
German cockroach

German cockroaches, with rare exception, are found within human structures. They prefer to frequent kitchens and bathrooms where a constant source of water is usually available. The cockroaches will remain hidden during the day in areas behind appliances, under sinks, in cabinets and behind baseboards. However, German cockroaches are not limited to occupying specific areas. In hospitals, they have been found in the hollow metal legs of food service carts and within bed railings. They can become a problem in food service and equipment areas in commercial establishments such as restaurants and supermarkets. At night they will leave the safety of their harborage areas to seek food and water.

Asian cockroach (*Blattella asahinai*). Both adults and nymphs of the Asian cockroach appear nearly identical to German cockroaches. Distinguishing Asian cockroaches from German cockroaches is accomplished through their differing behavioral characteristics. While the German cockroach is an indoor species that does not fly, the Asian cockroach is an outdoor species that flies readily and well. The Asian cockroach breeds in mulch, leaf litter and grassy areas outdoors. During heavy infestations of this cockroach, grass will shimmer and appear to move as the cockroaches move about. Additionally, Asian

cockroaches swarm to lights and lighted areas during dusk. During the evening when lights are turned on indoors, Asian cockroaches will fly into homes and create a nuisance for homeowners. It has been reported that Asian cockroaches can become established within homes, but their primary pest status is derived from the fact that they are flying insects that invade porches and the interior of homes. It may be difficult to pinpoint the source of an Asian cockroach problem because they may be breeding in areas other than where they create problems. Therefore, attempts at control should take into consideration the fact that they are proficient flyers and may be invading from neighboring areas.

Brownbanded cockroach (*Supella longipalpa*). Brownbanded cockroaches may be mistaken for German cockroaches because of their similar size. However, brownbanded cockroaches may be easily distinguished by their markings (Figure 4.7). Nymphs have distinct, light-colored bands extending latitudinally across the back of the body region. They also possess lighter markings around the edges of the pronotum. Both adult male and female brownbanded cockroaches possess wings.

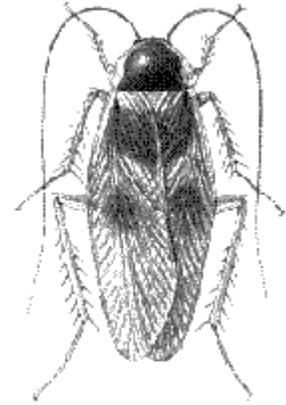


Figure 4.7.
Brownbanded cockroach

Brownbanded cockroaches are found primarily in homes and prefer **harborage** in high areas such as in closets and behind picture frames and moldings. They prefer drier areas than do German cockroaches and are not associated with kitchens and bathrooms. It has been reported that brownbanded cockroaches will fly within homes and may be seen flying around light structures. Female brownbanded cockroaches will deposit egg cases in a variety of areas, including furniture and linens. Egg capsules are approximately 5 mm long and carry approximately 10 to 20 nymphs.

American cockroach (*Periplaneta americana*). This cockroach is a large species, measuring approximately 3.8 cm in length as an adult. The nymphs are patterned dark reddish-brown and yellowish-brown and do not possess wings. Adult males and females are very similar in appearance, with the female having a somewhat wider and more rounded abdomen than the male. Additionally, an egg capsule is often seen protruding at least partially from the abdomen of the female, further aiding in identification. Males have two sets of thin, pointed appendages (**cerci** and **stylets**) at the tip of the abdomen, whereas females have only one set of cerci. Both male and female American cockroaches are a uniform dark brown to reddish-brown, with a dark yellow band encircling and dividing the pronotum (Figure 4.8). Adults of both sexes possess fully developed wings and are capable of flight.

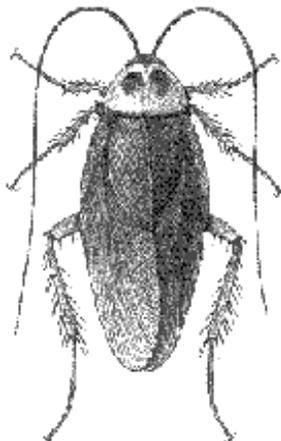


Figure 4.8.
American cockroach

American cockroaches tend to breed in cool, damp, dark locations such as sewers, basements and gutters, and they readily infest commercial establishments where food preparation occurs. They can become established in homes by entering through conduits such as plumbing or sewer lines, or migrating from basement areas. Once established within a home, American cockroaches will thrive, given access to food, water and preferred temperatures. Females produce approximately one egg capsule per week and will glue the capsule to any available **substrate**. Egg cases have been found on ceilings, in furniture, along baseboards and in cabinets. After the nymphs hatch, the split egg case will remain glued in place, providing evidence that cockroaches were present. Close relatives include the brown cockroach, smokybrown cockroach and Australian cockroach, all associated with harborage in plants but capable of building sizeable populations in dwellings.

Oriental cockroach (*Blatta orientalis*). Oriental cockroach nymphs are very dark brown to black and are sometimes referred to as “black beetles.” Male and female adults are distinctly different in appearance. Adult females resemble large nymphs but have venation in the wing pads that is not present in nymphs. They have a much broader, rounder abdomen than do males. Additionally, males possess wings, whereas females do not. Although the males do have wings, they are relatively short, not extending to the abdomen. Neither male nor female oriental cockroaches are capable of flight.

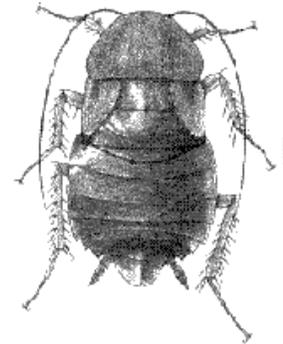


Figure 4.9.
Oriental cockroach

Oriental cockroaches prefer much cooler temperatures than those found in the southern regions of the U.S. Therefore, oriental cockroaches are primarily pests of northern regions. They are usually found in large groups, either in houses or outdoors. When found in homes, they tend to congregate in dark, damp basements. Once established, they can and will move upward into a home via water pipes. Females deposit their egg cases near food sources. Females carry egg cases up to five days before depositing them. Egg cases may take up to two and a half months to develop, depending on environmental conditions.

Woods cockroaches (*Parcoblatta pennsylvanica*, other *Parcoblatta* spp. and *Eurycotis floridanus*). There are several species of woods cockroaches in the U.S. Although they have similar common names, the species of woods cockroaches are very different in appearance. Males of the northern species (*P. pennsylvanica*) have fully functional wings and will fly readily, whereas the females have wing stubs and cannot fly. Southern species of woods cockroaches (*E. floridanus*) are black, large-bodied cockroaches. Neither males nor females can fly as they do not possess wings. Both northern and southern species of woods cockroaches are notable primarily because they are occasional invaders in homes but usually do not take up residence. Woods cockroaches, in general, prefer to live under bark, dense leaf mats and within rotting logs. Pennsylvania woods cockroach species are primarily found on tree trunks, but the females may be found either on trees or in ground nesting sites. One distinctive characteristic of the Florida woods cockroach is that it emits a foul, rotten citrus odor when disturbed. The smell of the defensive secretion alone can be a key diagnostic characteristic.

Detection and Control

When cockroach populations are small, detection by the homeowner or apartment dweller usually occurs at night during cockroach foraging periods. However, when moderate to large infestations are present, cockroaches may forage during the day or harbor in open areas, making them readily observable. Cockroaches are also detected because of the frass they leave behind, such as fecal material and hatched egg cases. They are also noticeable by the very distinct odor produced when present in large numbers. To determine the location of hidden **harborage** areas, pest-control technicians use flashlights and **flushing agents** to pinpoint the exact sources of infestations.

Specific control measures vary by species, but for all cockroaches integrated pest management (IPM) is the most effective method for control or elimination of an infestation. The elements of a successful IPM program include identification, sanitation, exclusion, trapping/physical removal and chemical treatment.

Identification, sanitation and exclusion. Identification of a cockroach pest is essential in determining how best to proceed with IPM. Several species may be very similar in appearance but vastly different in habitat and behavior. For example, German and Asian cockroaches are almost identical in appearance but live in completely different habitats that require different control measures.

Sanitation both before and after an infestation will greatly augment any control program. Sanitation primarily involves the reduction or elimination of food and water sources. Limiting access to food sources by such measures as refrigeration, secure containers and regular cleansing of food preparation surfaces is a basic step. Without access to food and water, cockroaches will have difficulty surviving. Sanitation also includes the reduction of **harborage** areas. It is impossible to eliminate all harborage sites, but by reducing unnecessary clutter within a structure, cockroach harborage areas are also reduced. For Asian cockroaches, sanitation/elimination of harborage areas includes the removal of mulch and leaf litter from around homes.

Exclusion is another effective tool in the IPM arsenal. By preventing cockroaches from entering a structure, the need for other control methods is eliminated. Exclusion is particularly effective against the large, outdoor species of cockroaches that may crawl in under door frames or through loose screens. Caulking, applying weather strips and replacing damaged or missing screen can prevent entry by not only cockroaches, but other pest insects as well.

Trapping/physical removal. Sticky traps are used to monitor and reduce cockroach infestations. Sticky traps can aid in the determination of how severe an infestation is, which helps to determine what further control measures may be necessary. Additionally, any cockroaches caught in sticky traps are removed from the population, resulting in a reduction of an infestation. However, cockroaches cannot be eliminated through the use of sticky traps alone.

After monitoring the severity of a cockroach population through proper placement and use of sticky traps, physical removal of cockroaches will further assist in the reduction of a cockroach population. Physical removal may be accomplished through the use of specially designed vacuums equipped with high-efficiency particulate air (HEPA) filters. It is important that a HEPA filter be used when vacuuming to trap cockroach particulate debris. Cockroaches are a significant source of allergens, and the proteins found in their cast skins and dead bodies can create both asthma and allergies. A well-designed vacuum with a HEPA filtering system can dramatically reduce or eliminate the potential for blowing particles from cockroach harborage areas out into the open. Depending on the size of an infestation, efficient vacuuming can be a major factor in the rapid reduction of a cockroach population.

Chemical treatment. Chemical control methods may vary with different species of cockroaches. The sites for chemical control of Asian, German and American cockroaches differ for each species as they will infest different areas of a structure. Asian cockroaches fly in from the outside, German cockroaches primarily infest kitchens and bathrooms, and American cockroaches prefer sewers and basements. The most accepted methods of chemical control of cockroaches are insecticidal baits and perimeter spray treatments.

Insecticidal baits have proven quite effective in the control of cockroach pests and have replaced general spraying of baseboards and surfaces. Proper bait placement involves precision targeting for specific cockroach pests. For German and American cockroaches, baits can be placed exactly where they are most effective, especially in foraging and harborage areas. Insecticidal paste and gel formulations are used as baits in crack and crevice treatments to attain maximum exposure.

The baits in use today provide both primary and secondary kill of cockroaches. Through primary kill there is direct kill of the cockroaches that feed on the bait. Because current baits are often slow-acting, the cockroaches that die from direct kill do so after they have returned to harborage areas, often after they have eliminated some of the bait through their feces. The fecal material and the dead cockroaches themselves are then consumed by other cockroaches, which are then also killed by the active chemical

ingredient of the bait. These treatments can be supplemented with spot spray applications (2 square feet or less) of conventional insecticides or IGR/insecticide mixtures at strategic locations. The mixtures target rapid kill and long-term suppression of cockroach reproduction.

Perimeter sprays are often used as a barrier treatment to prevent cockroaches, and other pests, from entering structures. There are a variety of chemical sprays available, some more effective than others. The drawback to perimeter spray treatments is that they are vulnerable to the external environment and factors such as rain and sun. Therefore spray treatments must be conducted on a regular basis to ensure the chemical barrier has not been compromised. Perimeter spray treatments are most effective against American, smokybrown and brown cockroach species. Perimeter sprays are not particularly effective against Asian cockroaches, which fly rather than crawl into structures and may not contact treated areas. For Asian cockroaches, a combination of baiting and targeted chemical spraying of breeding areas is the most effective chemical treatment method.

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