



Bed Bugs: For Homeowners

Ryan S. Davis
Arthropod Diagnostician

Erin W. Hodgson
Extension Entomology Specialist

Jay B. Karren
Extension Entomology Specialist

Alan H. Roe
Insect Diagnostician

What You Should Know

- Bed bugs are one of the most difficult indoor pests to eradicate; hiring a pest control company is highly recommended.
- Bed bug control is intensive, and two or more visits from your pest control company are likely necessary to achieve control.
- Select a pest control company based on their bed bug experience and knowledge; the cheapest company is not always the best choice.
- Even experienced pest control companies may not successfully eliminate bed bugs on the first series of treatments.
- To optimize treatment effectiveness, you must follow directions provided by your pest control company.
- You can supplement professional pest control treatments with control tactics of your own, including steam cleaning, washing and drying textiles on the hot cycle, and using diatomaceous earth dust.
- When traveling, take the proper precautions to avoid bringing bed bugs back to your home (see "Travelers' Tips on page 5)



Fig. 2. Immature and adult bed bugs often huddle together.¹

Bed bugs are notorious around the world for their impact on humans and have been recognized as important pests for hundreds of years. Infestations were common before World War II, but heavy insecticide use eliminated most bed bugs in North America for almost 30 years. However, increased international travel and the removal of long-residual insecticides (DDT, Lindane) from the market have recently allowed bed bugs to make a comeback. The human bed bug, *Cimex lectularius*, (Fig. 1) is the most common species in the U.S. and Canada. Bed bugs are blood-feeding insects in the order Hemiptera and family Cimicidae. These insects are related to other fluid feeding true bugs such as squash bugs and boxelder bugs, but are closely associated with warm-blooded animals like humans.



Fig. 1. Adult bed bug *Cimex lectularius*.¹

Description and Life Cycle

Human bed bugs are small oval insects that are flattened top to bottom, but visible to the unaided human eye. Adults are always wingless and may resemble immature roaches, aphids, ticks, or other immature true bugs (Fig. 1). Bed bugs are normally brown in color, but become red and bloated after feeding. Their flattened shape allows them to hide in spaces as narrow as a business card, or in the holes of staples. Nymphs look similar to adults except smaller, and are nearly colorless or pale yellow (Fig. 2). Newly hatched bed bugs are about 1mm long, while adults reach 6 mm. All life stages have

a short, 3-segmented straw-like mouthpart, and 4-segmented antennae. Like mosquitoes, the "straw" is made of two tubes, one for injecting a numbing agent and blood thinner, and another for sucking the blood out of your body. Both sexes can pierce animal tissue and remove blood with a pain-free bite. Bed bugs mostly feed at night and early morning, but can occasionally feed during the day. Hosts of the common bed bug include humans, mice, rats, rabbits, guinea pigs, horses, cattle, and poultry.

On average, bed bugs complete a generation (egg to egg) in 1.5 to 2 months, but can range from 1 to 4 months depending on temperature and accessibility to blood meals (Fig. 3). Bed bugs go through 5 immature stages called instars. Every immature must feed in order to molt to the next instar. Adults must feed to produce eggs and sperm. Later instars and adult bed bugs can survive for well over a year without feeding if conditions are favorable (Table. 1).

After mating, females can begin laying eggs in 3 to 6 days, and can lay 200 to 500 eggs over a life span of 6 to 18 months. On average, bed bugs lay 5 eggs per week. Eggs are oval-shaped and white, and are about

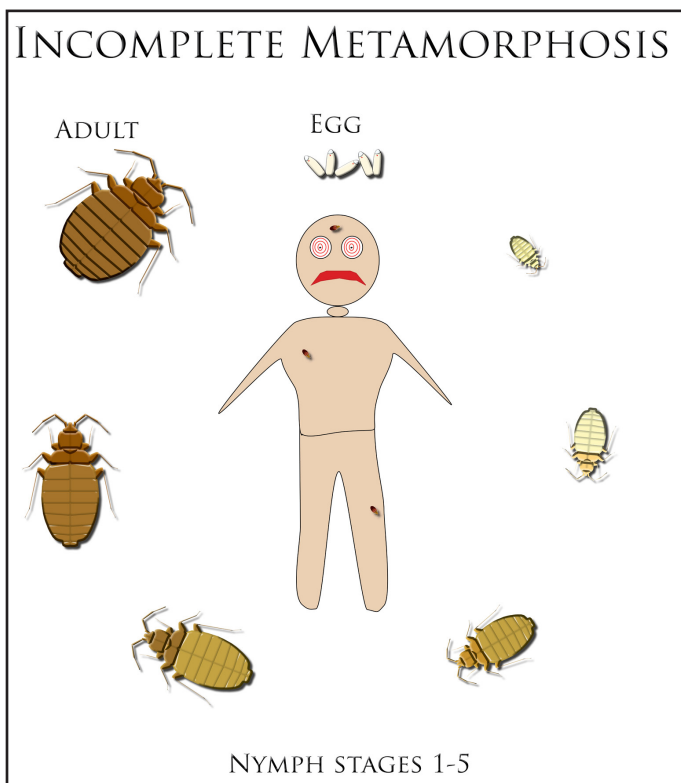


Fig. 3. Bed bug (*C. lectularius*) life cycle: egg, 5 instars (immature stages), and adults. Bed bugs must feed to molt to the next developmental stage, and for reproduction.

1 mm long--visible to the unaided human eye (Fig. 4). Eggs take 7 to 10 days to hatch, and can be resistant to insecticide treatment. Because of this time require-

ment for egg hatch and egg resistance to insecticides, a follow-up insecticide treatment is necessary 2 weeks after the first. Because of the number of eggs laid per week, populations can grow into the thousands in just one month!

As with some other insects, all life stages can be found living in large groups, but bed bugs may live solitarily, too. In addition to cast skins from molting, "blood" droplets can be an indication of a bed bug infestation. After each blood meal, bed bugs excrete reddish-brown/purple-blue fecal spots on or near the host, or in their daytime hiding places. There are several related species in Utah that can be mistaken for bed bugs, including: 1) bat bug (*Cimex pilosellus*), 2) barn swallow bug (*Oe-viacus vicarius*), and 3) poultry bug (*Haematosiphon in-odorus*). The treatment of these species is different than for bed bugs, so have the specimen identified before planning a control strategy.

Bed Bug Behavior

Bed bugs are secretive, nocturnal insects that emerge from hiding places at night to feed on nearby hosts. Although bed bugs are wingless, they can travel over 4 feet per minute, and travel an average of 20 feet in search of food. In extreme cases, bed bugs have been recorded traveling over 60 feet in search of food. Host searching occurs in three stages: 1) random searching, where bugs walk around searching for a host or chemical/physical host cues, 2) CO₂ gradients allow bed bugs to find their way toward a carbon dioxide-exhaling host, and 3) host body temperature will attract bed bugs once in close proximity. The bed bugs will test the host until a suitable blood vessel is found, which may lead to multiple bites from the same bug. In the absence of human hosts, bed bugs can survive on blood meals from household pets or rodent pests.

Bed bugs prefer to feed on exposed bare skin (face, neck, shoulders, arms, hands, etc.). If left undisturbed, a bed bug can obtain a full blood meal in three to five minutes, but averages about 15 minutes. After feeding, they will quickly retreat into hiding. They are sensitive to movement, and will withdraw their mouthparts if disrupted. Feeding will resume in a new location once the disruption has stopped, leading to multiple bites. Individual bed bugs do not feed every night, but must feed before each molt. Typically, nymphs and adults feed every five to seven days if blood is available. Optimal feeding temperature is 80°F, but they can feed when temperatures are below 50°F. Bed bugs can live a long time without feeding, so vacating a residence to "wait them out" is not effective (Table 1).

During the night, bed bugs hide in enclosed places such

Survival of Bed Bugs in Days After Feeding		
Stage	50°F	80°F
1st Instar	275	28
2nd Instar	399	46
3rd Instar	413	71
4th Instar	433	73
5th Instar	485	40
Adult Female	425	87
Adult Male	402	43

Table. 1. Bed bug survival between blood meals in days after feeding (data adapted from Pinto, 2007²).

as along furniture seams, headboards, night stands, even under wall paper or in wall cracks. Because bed bugs are relatively flat and small, they can fit into almost any space, going undetected without careful inspection. They can infest all rooms in a house, not just a bedroom. Recent data from 16 infested one-bedroom apartments shows where bed bugs prefer to hide³:

- 60% in box springs
- 22% in mattresses
- 13% in sofas and chairs
- 4% in bed frames
- 1% in other areas

Given the bed bugs' small size they can be easily transported on clothing, luggage, blankets, and furniture. If you decide to move to the couch or recliner to take nightly refuge, they will follow you! They can move from room to room, or between apartments or hotel rooms via wiring and pipes in wall voids, especially if repelled by a pyrethroid application, or if seeking food in the absence of their primary host (you).

Bed bugs are unknowingly being spread in second-hand stores and via rental/refurbished products, such as mattresses. Always inspect second hand or refurbished furniture/beds, and rental furniture for bed bugs before you bring them into your house.

Medical Importance

Bed bugs are parasites that generally do not kill the host; however, heavy infestations can weaken small animals, such as pets. Fortunately, there is no evidence that bed bugs transmit diseases. Typically, humans do not notice bed bug feeding at first because it happens during the night. Over two to seven days, the bite area may itch, swell, burn, become inflamed, or form a welt. Effects of a bite vary with the individual, but may persist for a week or more in susceptible persons. Symptoms may worsen with multiple bites, although some people have no adverse reaction to bed bug bites.

Often bed bug bites are attributed to other insects or spiders and may go unnoticed for a time. As a result, colonies can increase before they are detected. It is important to recognize that not all bites are caused by bed bugs. An infestation is confirmed by finding actual bed bugs, which may take a professional. The chances of encountering bed bugs is greater for people who travel. Bed bugs should be suspected if you wake up with red, swollen bites you did not have when you went to sleep, or notice itchy bumps on skin that is exposed at night.

Choosing a Pest Control Company

Do not try to eliminate bed bugs on your own--you will likely fail. Begin by calling a minimum of three pest control companies. Cheapest is NOT always best! Choose a company based on their past bed bug experience and success, knowledge of bed bug biology and habits, and the quality of their management plan. If a company does not have a plan in place for bed bug management, then do not choose them.

Remember, bed bugs are probably the most difficult indoor pest to eliminate--even well-seasoned pest control companies can't guarantee 100% elimination of bed bugs--be wary if they do. Companies are not trying to take advantage of you if they say they need to treat multiple times. If they don't require multiple treatments (two or more treatments on 2-week intervals) then they are not well educated on bed bug biology. If you cannot find a reputable local pest control company, select a larger, national company. See the bullets below for tips on selecting a pest control company.

Tips for Selecting a Pest Control Company; a quality pest control company will:

- not make the claim they will eliminate bed bugs
- price according to the thoroughness and amount of work necessary to eliminate bed bugs
- have a well thought-out management plan
- provide education to client about bed bugs via a verbal or written format (such as this fact sheet)
- tell you your responsibilities up front
- perform a detailed inspection before every application and at least 2 weeks after the final treatment
- have technicians that show an in-depth understanding of bed bug biology
- have successfully treated many bed bug infestations

- possess a license and insurance
- take detailed notes during spray treatments and inspections
- ask that tenants prepare a residence for spraying/inspections--bag washed and dried bedding, clothes, towels, etc., empty drawers and closets, open closets, furniture, and more
- recommend bed bug proof mattress and box spring covers to supplement their treatments
- use multiple formulations of insecticides (liquids, dusts, and aerosols)
- vacuum/steam clean carpets, mattresses/box springs, furniture, etc.
- make a minimum of two treatments/inspections, and may exceed three

Improving the Odds of Control

One of the major barriers to successful bed bug management is the lack of understanding from the client. If the pest control company asks you to take certain steps to help them, do them. There are tactics you can use to supplement a company's program. Complete the items below to increase the chance of success:

- launder *all* household textiles weekly to maximize control, especially before inspections and treatments and store in garbage bags or air-tight containers
- be prepared for inspection/treatment in advance, which includes laundering textiles, emptying drawers, cabinets, and cleaning clutter that may obstruct successful inspection or treatment
- use bed bug-proof mattress and box spring covers after first treatment (make sure covers are tested and approved for bed bugs--not all covers are effective--Protect-A-Bed is one approved brand)
- vacuum/steam clean carpets, furniture, drapes, etc. weekly; make sure not to transport bedbugs in vacuum
- minimize harborage sites by eliminating clutter, especially items stored under the bed; repair cracks, holes, crevices, etc., inside the home
- create a management plan to stop the re-introduction of bed bugs after a successful treatment



Fig. 4. Bed bug (*C. lectularius*) eggs (~ 1mm long)¹.

- construct or purchase monitoring traps to obtain a more accurate estimate of densities and measure the success of treatments
- supplement chemical treatments by using diatomaceous earth (DE) around baseboards and anywhere you suspect bed bugs might crawl (DE can be an effective, low hazard way to eliminate bed bugs)
- when traveling, make sure you don't bring bed bugs home with you: see "Travelers' Tips" on page five

When implementing the strategies listed above, take care not to translocate bugs around the house and to other places.

Bed Bug Monitoring

There aren't many effective devices for monitoring bed bugs. One device, however, is fairly inexpensive and will allow you to monitor for bed bugs before and after treatments, as well as supplement personal and professional control efforts. Climb-up bed bug interceptors can help isolate your bed or furniture from bed bugs remaining in your house (Fig. 5). Furniture legs can be placed in the middle of the interceptor, in addition to a layer of diatomaceous earth for insecticidal action. Bugs trying to crawl up or down the bed will be caught in the slick-sided device. You can check the devices daily to monitor bed bug activity. If you do not want to purchase these, you can make one on your own. Please read Wang ^{a3}, ^{b4} for directions on constructing this device.

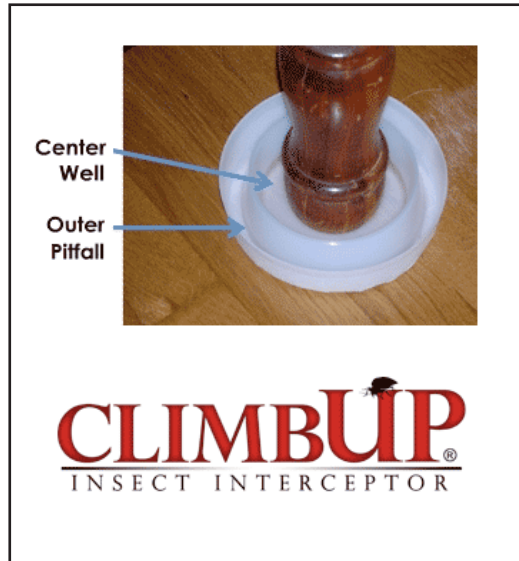


Figure 5. Insect Interceptors can be beneficial additions to your bed bug management strategy⁵.

Travelers' Tips

Because bed bugs are more prevalent in areas with high people traffic, places like hotels, hostels, bed and breakfasts, etc., are common places to pick up bed bugs. The quality of the hotel does not matter, a 5-star hotel is as susceptible to bed bugs as a 1-star motel. Follow the tips below to minimize the chance of bringing bed bugs home with you.

- Travel with duffle-bag style luggage. These bags have minimal seams (i.e., hiding places for bugs) and can be laundered if infested.
- When checking in to a hotel, leave your possessions in your car. First go to your room and inspect the mattress (remove bedding), box springs (top and bottom), the bed frame and where the frame meets the floor, head boards (many headboards attached to the wall are removable), baseboards, furniture and pictures near the bed.
- Purchase plastic, bed-bug proof encasements for your luggage.
- Upon waking, thoroughly check the pillow cases and bedding for bed bug fecal spots (will look like small, dark blue blotches of ink). If you see spots assume your room has bed bugs and that they are in your possessions.
- Put all possessions into thick plastic bags, duffle bag included.
- Separate clothing (light, dark, delicate, etc.) when bagging so you won't have to do it at home.

- Wash and dry clothes on the high heat cycle (as high as the clothes will allow without harming the fabric). If you use a laundromat or dry cleaning service let them know your clothes might contain bed bugs.
- Before you travel, visit the bed bug registry to view hotels that have been reported to, at one time, have bed bugs: <http://bedbugregistry.com>.

Early Detection is Important

- Bed bugs are often brought into buildings with luggage or used furniture. If you suspect an infestation, check for activity where luggage is stored.
- Fecal blood spots are a good indication of an active bed bug infestation. Look for small, dark droplets of dried, digested blood on bedding, mattresses, and bedroom furniture. Colonies will try to hide in small cracks, especially where the floor meets with the wall.
- Colonies tend to be near beds or where people rest. In particular, thoroughly inspect bed frames, mattresses, box springs, headboards and other furniture located near the bed.
- Bed bugs can also be found in other parts of the house, including living rooms, laundry rooms and places where clothing is stored. Look behind wall hangings, clocks and around pet kennels for signs of cast skins or small blood droplets.
- Bed bugs and bird bugs can be found on animals nesting in a home attic, and eventually feed on pets and humans.
- Sometimes bed bugs release an offensive odor with oil glands in the body, although the odor may only be detectable with heavy infestations.
- Reducing clutter around the home will improve the chances for early detection and minimize potential hiding places for bed bugs.

Control Options

Unfortunately, bed bugs are difficult to control because of their size and hiding behavior. A professional pest control company should be notified if bed bugs are detected. Professionals are recommended because complete eradication can only be achieved with very detailed inspections and restricted-use insecticides. Professionals know where to look for bed bugs and have special tools to estimate the extent of infestation.

Sanitation: Deep cleaning the entire home or building is the first step, including vacuuming and steam cleaning every piece of furniture and luggage, and cleaning all the floors, walls and ceilings. Often pictures, furniture, toys, and electronic equipment must be disassembled.

Temperature treatments: All fabrics, including clothing, blankets and bedding should be inspected and washed. Infested fabrics should be laundered (140°F minimum) or discarded. Bed bugs can also be killed with cold treatments by chilling infested materials below 32°F for at least two weeks.

Insecticides: Bed bug control is expensive and can take several weeks or months. Products effective against bed bugs are restricted use chemicals only available to commercial applicators. Professional pest controllers have access to a variety of low-odor sprays, dusts, and aerosols. In addition to non-chemical control tactics, two or more applications are needed for effective control. Home owners may purchase and use diatomaceous earth to supplement the pest control company's treatments.

Homeowner “Do Nots”

- Do not try to chemically treat bed bugs on your own.
- Do not use bug bombs, these are not effective killers of bed bugs, and may actually make problems worse by repelling bed bugs into adjacent living areas.
- Do not move from room to room in an attempt to escape bed bugs--this will cause the bugs to spread--they will find you.
- Do not select a pest control company based on price alone--experience is the most critical aspect.
- Do not leave and attempt to “wait-it-out”, the bugs will be there when you get back--and they will be hungrier than ever
- Do not bring bed bugs home in luggage or personal effects when traveling.

Further Reading

²Pinto, L.J., Cooper, R., and Kraft, S.K., 2007. Bed bug handbook: the complete guide to bed bugs and their control. Pinto and Associates, Mechanicsville, MD.

³Wang, C., Gibb, T., and Bennett, G.W., 2009. Evaluation of Two Least Toxic Integrated Pest Management Programs for Managing Bed Bugs (Heteroptera: Cimicidae) With Discussion of a Bed Bug Intercepting Device. *Journal of Medical Entomology*, 46(3):566-571. Entomological Society of America.

⁴Wang, C., Gibb, T., and Bennett, G.W., 2009. New interceptors assist in bed bug monitoring: New research examines the effectiveness of interceptors. *Pest Control Technology*, April, pg. 118.

Picture Citations

¹Images courtesy of Gary Alpert, Harvard University, Bugwood.org.

⁵http://www.bedbugsupply.com/Climbupamptrade-Insect-Interceptors_p_22.html#. Accessed January 8, 2009.

Precautionary Statement: All pesticides have benefits and risks, however following the label will maximize the benefits and reduce risks. Pay attention to the directions for use and follow precautionary statements. Pesticide labels are considered legal documents containing instructions and limitations. Inconsistent use of the product or disregarding the label is a violation of both federal and state laws. The pesticide applicator is legally responsible for proper use.

Utah State University is committed to providing an environment free from harassment and other forms of illegal discrimination based on race, color, religion, sex, national origin, age (40 and older), disability, and veteran's status. USU's policy also prohibits discrimination on the basis of sexual orientation in employment and academic related practices and decisions. USU employees and students cannot, because of race, color, religion, sex, national origin, age, disability, or veteran's status, refuse to hire; discharge; promote; demote; terminate; discriminate in compensation; or discriminate regarding terms, privileges, or conditions of employment, against any person otherwise qualified. Employees and students also cannot discriminate in the classroom, residence halls, or in on/off campus, USU-sponsored events and activities. This publication is issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Noelle E. Cockett, Vice President for Extension and Agriculture, Utah State University.