

FRONTISPIECE

*Cimex lectularius* Linnaeus. Left, female; right, male; above, cluster of nymphs and adults (Terzi).

Color illustration of bed bugs from Monograph on Cimicidae, by R.L. Usinger

# BED BUG HANDBOOK

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## BED BUG HANDBOOK



### INTRODUCTION

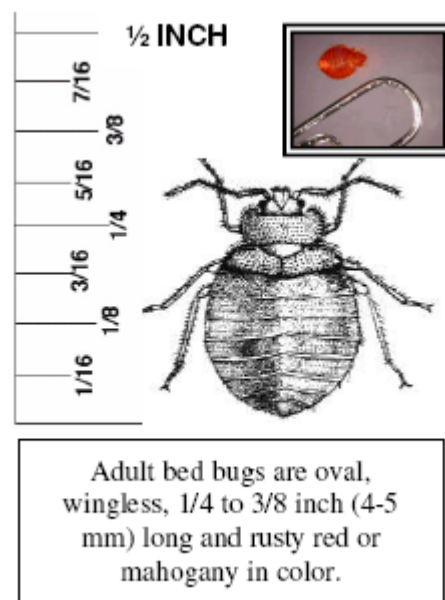
Bed bugs were once a common public health pest worldwide, but declined in incidence through the mid 20th century. Recently however, bed bugs have undergone a dramatic resurgence and worldwide there are reports of increasing numbers of infestations. There have been some anecdotal references that bed bug problems are on the rise because of increased tourism and changes in cockroach management shifting to an emphasis on using baits and reducing the use of liquid insecticides that may have coincidentally controlled bed bugs in the process.

Georgia Department of Human Resources, Division of Public Health provides primary prevention through a combination of surveillance, education, enforcement, and assessment programs designed to identify, prevent and abate the environmental conditions that adversely impact human health. One of the many mandates for the Environmental Health Section of Public Health is that of inspecting tourist accommodations in order to "minimize illnesses and injuries associated with unsanitary or hazardous conditions in Georgia's lodging industry." County Environmental Health Specialists working for the local health authority inspect these facilities twice a year and when there is a complaint.

Bed bugs are becoming a problem within residences of all kinds, including homes, apartments, hotels, cruise ships, dormitories and shelters. While we associate bed bugs with unsanitary conditions, the problem may be found in the cleanest of homes, hotels or other buildings. The purpose of this handbook is to provide basic information about the biology and health significance of these pests, to offer guidance on inspection for bed bugs, and to provide information on how to safely and effectively manage an infested residence or hotel.

### BIOLOGY

Bed bugs are small wingless insects that feed solely upon the blood of warm-blooded animals. They are sometimes mistaken for ticks or cockroaches. A mature bed bug is oval-bodied, brown to red-brown in color, wingless and flattened top to bottom. Unfed bugs are 1/4 to 3/8 inch long and the upper surface of the body has a crinkled appearance. A bed bug that has recently fed is engorged with blood, dull red in color, and the body is elongated and swollen. Eggs are white and are about 1/25 inch long. Newly hatched bed bugs are nearly colorless or straw-colored.



Of the 90 or so species in the family Cimicidae approximately 7 will feed on human blood, but only 2 are commonly found: *Cimex lectularius* (bed bug) and *Cimex*

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*hemipterus* (tropical bed bug). However, some species that are bird ectoparasites will bite humans who come into contact with infested bird nests.

### Life Cycle

Female bed bugs deposit 3 to 8 eggs at a time; a total of 200-500 eggs can be produced by one female over her 10 month life span. The eggs are 1/25 inch long and are slightly curved. They are usually deposited in clusters and fastened to cracks and crevices or rough surfaces near adult harborages with a sticky cement-type substance.



The eggs hatch in 4-12 days. The newly hatched nymph is nearly colorless or straw-colored before feeding, and then turns red or purple in color after taking a blood meal. Bed bugs go through 5 nymphal stages before reaching maturity. This usually takes 35-48 days. Nymphs look like small adults with the exception that adults have minute wing pads; females are larger than

males. Nymphs can survive months without feeding and adult bed bugs can survive for 6-7 months without a blood meal. They have been known to live in abandoned houses for at least a year. Under favorable conditions (70-90° F), the bugs can complete development in as little as a month, producing three or more generations per year. Cool temperatures or limited access to a blood meal extends the development time.

### Habits and Habitat

Bed bugs are active mainly at night; they reach peak activity before dawn. During the daytime, they prefer to hide close to where people sleep. Their flattened bodies enable them to fit into tiny crevices - especially those associated with mattresses, box springs, bed frames, and headboards. Bed bugs do not have nests like ants or bees, but do tend to congregate in habitual hiding places. Bed bugs do not fly, but can move quickly over floors, walls, ceilings and other surfaces.

Bed bugs respond to warmth and carbon dioxide when searching for a blood meal, but not to odors. All nymphal stages and adults of both sexes require blood for nutrition and development. Bed bugs ordinarily feed within 24 hours of hatching, once between each molt and once before egg deposition; an average period of 8 days is required between molts. Adult females will continue to take blood meals every 3-4 days depending on ambient temperature and humidity. Bed bugs take up to 10 minutes to complete a blood meal, and will consume 2-5 times their own body weight in blood during that time. Individual bed bugs usually do not feed every night but at



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intervals of a few days to a week. Once a bed bug is finished feeding, it quickly retreats back to its hiding place. They do not remain on the host between feedings. Bed bugs may also feed on small animals, such as pets.



Dark spots of bed bug excrement on a mattress. (M. Potter, Univ. of Kentucky)

Note that an irritation or bite experienced in bed may not necessarily be due to a bed bug infestation. A bed bug infestation can be diagnosed by the identification of specimens collected from the infected residence. Collection of live or dead bed bugs, cast skins, and hatched or un-hatched eggs will verify an infestation. The presence of bed bugs in a dwelling should be suspected if there are fecal spots on the bed clothes and on potential harborage areas and the distinctive sweet, musty, sickly smell emitted by bed bugs is present. Blood-spotting on mattresses and nearby furnishings is also often a tell-tale sign of an infestation.

### Movement

Some of the most common ways new bed bug infestations may be introduced include:

- Spending a night (or longer) in an environment which is already infested by bed bugs (hotels, homes, international flights, etc).
- Having someone visit from such an infested environment (bed bugs can be transported in luggage).
- Renting furniture or buying used furniture or bedding.
- Picking up discarded bedding or furniture from a curbside, trash collection point, or dumpster.

### Medical Importance

The bite of a bed bug is painless. The amount of blood loss due to bed bug feeding typically does not adversely affect the host. Unlike flea bites, which occur mainly around the ankles, bed bugs feed on any bare skin exposed while sleeping (face, neck, shoulders, arms, hands, etc). Skin reactions are commonly associated with bed bug bites, which result from the saliva injected during feeding. However, some individuals do not react to bed bug bites, while others note a great deal of discomfort often with loss of sleep from the persistent biting.

Common allergic reactions include the development of large welts, often >1cm, which are accompanied by itching and inflammation. The welts usually subside to red spots but can last for several days. Blister-like eruptions have been reported in association with multiple bed bug bites and anaphylaxis may occur in patients with severe allergies. In India, iron deficiency in infants has been associated with severe infestations. It



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has been suggested that allergens from bed bugs may be associated with asthmatic reactions. Reactions to the bites may be delayed up to 9 days before lesions appear. Reactions may be accompanied by severe itching that lasts for several hours to days. Scratching may cause the welts to become infected.



Bed bug

Bed bugs have been found to harbor at least 28 human pathogens and have been considered in the transmission of a wide variety of infectious agents. However, bed bugs have never been proven to biologically transmit any human pathogen, including HIV and hepatitis B. Although bed bugs are considered more of a nuisance than a health concern, public health officials maintain a level of interest due to the possibility of secondary infections.

### INSPECTING FOR BED BUGS

When bed bugs are suspected, a thorough inspection should be undertaken in areas where people sleep or rest. If the inspection site is a hotel, it is important that the housekeeping staff be interviewed. Such staff are more likely to have detailed knowledge about an infestation than the management. **Be sure that all inspections are done in the presence of hotel management or their representative and that permission has been obtained before staff disassembles furniture.**

Because bed bugs can hide in virtually any crack and crevice, efforts should be concentrated on dark, isolated and protected areas. Bed bugs prefer wood, paper and fabric surfaces and so these materials should receive special attention during the inspection process.



Bed bugs often congregate along the seams of mattresses and box springs.

The mattress should be the first site inspected and the seams, beading, under buttons, labels, and corner protectors (if not previously removed) should be examined closely. If headboards are attached to the wall, they should be removed after consulting



Bed bugs hidden beside a recessed screw under a nightstand. (M. Potter, Univ. of Kentucky)

maintenance staff. **Removing headboards from the wall is important, as this may be the first place bed bugs will be**



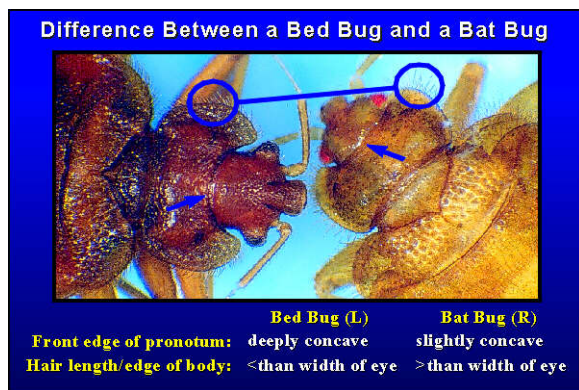
Bed bug fecal spots on a futon frame are a sign of a bed bug infestation

Photo by B. Ogg, UNL Extension in Lancaster County

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**found when the infestation is light.** For an ensemble, the base is more likely to harbor the bugs than the top mattress. The edge of the material underneath the ensemble base is a favorite spot for bugs as well as any hollow plastic caster legs. It will be necessary to remove the material covering the base of the bed. Generally, bed bugs are more likely to be present in the darker areas near the wall. For metal framed beds if wooden slats are present these contain many cracks for bed bugs to hide in and lay their eggs. If the wooden slats are bolted to the bed frame, the bolts should be undone and the drilled holes inspected. Bed bugs can also hide in coils of bed springs and inside hollow bed posts.

The areas around the bed should be investigated next, including the bedside furniture. The drawers in tables and cupboards should be removed and examined. Other furniture in the room should be inspected, especially locations where luggage is placed, such as luggage stands. For these, close attention should be paid to the seams and buttons (if upholstered) and any wooden joints (especially if constructed of chipboard). Other inspection sites include appliances such as telephones and stereo equipment, books, near electrical outlets and behind cover plates, underneath carpet thresholds, base boards, joints in floor boards and under floor boards, loose wallpaper and paint, old nail and screw holes, ornaments, window casings and wall voids. In moderate to severe infestations, bed bugs may be found higher on the wall in wall hangings, picture frames, wall mirrors, Venetian and vertical blinds, curtains and curtain rods, books, behind electrical conduit, cracks and joints in the ceiling, under wallpaper, under ceiling moldings, smoke detectors and light fittings.



In any infestation, the adjoining rooms, both sides, and above and below, should be inspected. Common rooms, such as a lounge, should not be overlooked. A room site plan should be drawn showing the location of any activity. The room inspection should be as methodical as possible noting all sites of bed bug activity on the site plan.

### Other "Bugs"

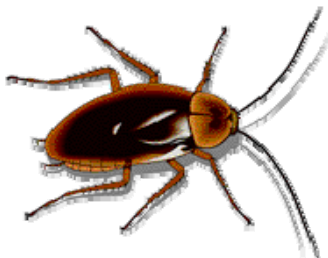
When bed bug-like insects are found, it is important

to consider whether bats, swallows, chimney swifts, pigeons, or other wild hosts are involved. Although similar in appearance, bed bug species that normally feed on bats and birds can be differentiated from those that prefer humans by using a hand lens

to examine the shape of the bug's head. Other species of bed bugs have appearances similar to the common bed bug. The bat bug is virtually identical but feeds upon bats and has longer hairs on its body than the bed bug. The barn swallow bug is similar in size and



Flea



Cockroach



Earwig

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coloration but is clothed with long silky hairs. The poultry bug or Mexican chicken bug is more active than the common bed bug, has longer legs, and a longer beak.

There are other insects and arthropods that can invade buildings and that might be confused with bed bugs. These include roaches, other hemipterans (stink bugs, wheel bugs, etc), fleas, ants, beetles, and earwigs. The masked hunter, an assassin bug, is known to feed upon bed bugs. Presence of this insect in the home may be indicative of bed bug infestations, although this is not always the case.

(<http://www.ento.psu.edu/extension/factsheets/maskedHunter.htm>).

A key to common pests of man and animals can be found at <http://ipm.ncsu.edu/AG369/keys.html>.

### TREATMENT AND CONTROL

If bed bugs are found, the hotel management or homeowner should be encouraged to consult a **licensed pest control professional**. A written integrated pest management (IPM) plan should be requested from the pest control operator. This plan should detail the methods and insecticides to be used by the pest control operator and describe the efforts expected by the building manager. Generally, pesticides will need to be applied in conjunction with any non-chemical means of control; non-chemical options should be considered as management tools only. Good housekeeping practices and a reduction in possible harborages such as clutter, cracks, and crevices will discourage repeat infestations. As bed bugs are good at concealing their location, complete control is often difficult to achieve with the first treatment. This is especially so with heavy infestations and thus a post control treatment evaluation is always advisable. Below are some of the more common methods for dealing with bed bug infestations.

#### **Physical Removal**

Where infestations are heavy, treatment and removal of infested furniture and mattresses may be necessary. If bed bug numbers are small, they can be physically removed from mattresses and harborage sites by vacuuming. Because bed bugs can be distributed to other sites by equipment used to remove them, the vacuum should be bagged and used only for the purpose of removing bed bugs. The vacuum bag should be removed, sealed in a plastic bag, and properly disposed of in an outside dumpster. Vacuum every day or two until the bed bugs are gone. After the mattress is vacuumed or scrubbed and dried, it can be enclosed in a zippered mattress cover such as that used for house dust mites. Any bed bugs remaining on the mattress will be trapped inside the cover. Leave the cover in place for a year or so since bed bugs can live for a long time without a blood meal. After bed bugs are removed, cracks in plaster need to be repaired and loosened wallpaper glued down to eliminate bed bug harborage sites.

#### **Temperature Extremes**

Bed bugs are very sensitive to heat, and a combination of steam cleaning and insecticide use has been found to be more effective for long-term control than insecticides alone (Meek, 2003). However, the effectiveness of steam cleaning has



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been questioned, because the mattress can quickly absorb the heat and the bed bugs may not be harmed. Therefore, it is important to monitor the effectiveness of this or any treatment being used to control bed bugs. Steam treatments should start with the mattress and be applied to the seams, under labels and handles, and both inside and outside of the bed frame or base. Cushions of chairs and sofas should be treated next. Carpet edges can also be treated. It is important to be aware that steam cleaning can leave excess moisture, which can lead to problems with mold, mildew, house dust mites, etc.

Bed linens, towels, drapery, and other like items can be washed in hot soapy water and dried in a clothes dryer set to the highest setting that will not damage the items.

It is often recommended that items be placed into black plastic bags and put in the sun so that the heat will kill any bed bugs on or in the item. This is not likely to be effective with anything but very small items. Bed bugs are also sensitive to extreme cold, so placing of small items in bags and freezing them for a minimum of 4 days may also provide control in items that can not easily be treated in any other way.

### Chemical Control

Chemical control should be done by a licensed pest control professional using products labeled for bed bug control. Such applications are best done as "crack and crevice" treatments to gaps around baseboards and other similar places. Insecticidal dust formulations provide long residual in these locations. Pesticide applications to furniture, particularly mattresses, should be limited. Use products that are labeled for application to carpeting and furniture. The first application may not give complete or immediate control, and additional treatments may be necessary in 1 to 2 days. Space treatments ("fogging" and "bug bombs") are ineffective against well-hidden bed bugs and may cause bed bugs to scatter making eradication more difficult. **As with any pesticide, always read the label and follow directions and safety precautions.**

Some chemicals labeled for use in controlling bed bugs.	diatomaceous earth (PermaGuard)	Dust
	eugenol (Bioganic, Raid)	Aerosol spray, Dust
	imoprothrin (Raid)	Aerosol spray
	permethrin (Spectracide)	Aerosol spray
	pyrethrins, pyrethrum	Aerosol spray
	resmethrin (Spectracide)	Aerosol spray, Liquid
	tralomethrin (Raid, Spectracide)	Aerosol spray

### After Treatment

To avoid spreading the bed bugs to other buildings, the room or rooms should not be used until they have been found to be bug-free. In tourist accommodations the pest control professional should conduct an in-depth physical inspection to determine treatment effectiveness. The local Environmental Health Specialist should recheck

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the room(s) after they have been treated and re-evaluated by the licensed pest control professional to ensure that steps were taken to eliminate and prevent the bed bug infestation. Glue boards placed close by harborage areas may help monitor bed bug activity by catching bed bugs as they move about at night. Many times the first application does not seem to give complete or immediate control. Additional treatments may be necessary in 1 to 2 days. Reinspections should occur within a week.

### REFERENCES

Goddard, J. 2003. Do Bed Bugs Carry Human Diseases? Pest Control Technology, 31: 38-40.

[http://lrs.afpmb.org/YWUQZUBTB0HT9YSNTDNTT30K/arc/al\\_06\\_tit\\_fetch/11/177162](http://lrs.afpmb.org/YWUQZUBTB0HT9YSNTDNTT30K/arc/al_06_tit_fetch/11/177162)

Gordon's Key to Insect Orders

<http://www.earthlife.net/insects/orders-key.html>

Meek, F. 2003. Bed Bugs Bite Back. Pest Control Technology, 31: 43-52.

[http://lrs.afpmb.org/YWUQZUBTB0HT9YSNTDNTT30K/arc/al\\_06\\_tit\\_fetch/14/176328](http://lrs.afpmb.org/YWUQZUBTB0HT9YSNTDNTT30K/arc/al_06_tit_fetch/14/176328)

Instant Symposium: Not Letting the Bed Bugs Bite... Bed, Lab, and Beyond. American Entomologist. Summer 2006, 52 (2):98-122.

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### INFORMATION FOR THE ENVIRONMENTAL HEALTH SPECIALIST

Steps to take when inspecting a room for bed bugs:

- ◆ **Furniture must be inspected carefully**, even to the point of dismantling the bed for easier inspection and possible treatment. Check the mattress and boxspring carefully, particularly the seams and dust cover on the underside of the boxspring.
- ◆ **Check under and behind other pieces of furniture**, such as chairs, couches, dressers, etc. It may be necessary to remove the dust covers on the undersides of chairs and couches. Pull drawers out of dressers, inspect them carefully and examine the interior of the dresser. Check under lamps on nightstands.
- ◆ **Remove and inspect objects**, such as pictures, mirrors, curtains, etc., that are hung or mounted on walls.
- ◆ **Check obvious cracks and crevices** along the baseboards, particularly the back framing pieces.
- ◆ **Inspect torn or loose wallpaper** and decorative borders.
- ◆ **Check clothing and other items** stored in areas where bed bugs have been found.
- ◆ **Check attics, eaves and roof overhangs** for signs of bat or bird activity. Request old nesting material be removed. If there are bats roosting in the attic, have management contact a pest control company or wildlife removal company in the area for assistance.



From: <http://www.ces.ncsu.edu/depts/ent/notes/Urban/bedbugs.htm>

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### INFORMATION FOR THE HOTEL MANAGER/HOME OWNER

Steps to take to enhance pest control treatments and to eliminate an infestation more quickly:

- **Examine all items in infested rooms for bed bugs.** Look for black or brown fecal spots to pinpoint hiding places. Kill bed bugs by dropping them in hot, soapy water and flushing. Remember that immature bed bugs are very tiny. Don't forget to check under mattress buttons and between the mattress and box springs.
- **Launder bedding and dry** in a hot dryer to kill all stages of bed bugs.
- **Thoroughly vacuum** infested areas. This includes the mattress, box springs furniture, beds, headboards, and sofas. Do not forget the void area underneath box springs--tear away the cambric fabric and look for bed bugs there. After you are finished, bag the vacuum cleaner bag and take it to the outside trash dumpster. Bed bugs are very resistant to being killed and you do not want them crawling out of the vacuum cleaner to re-infest the building. Vacuum every couple days until the infestation is gone.
- **Use a steamer on mattresses** to kill eggs that might have been overlooked. Steaming is effective and safer than spraying mattresses with insecticides. Steam cleaning carpets is also a good idea, but work with the pest control company to make sure you are not interfering with the effectiveness of treatments. Be sure that mattresses dry completely to avoid mold and mildew.
- **Eliminate clutter** in infested areas to reduce bed bug hiding places and make treatments more effective. Stacks of clothing, paper items, and corrugated cardboard are likely hiding places because bed bugs like to hide in small cracks.
- **Repair cracks and crevices.** Eliminate harborage areas by filling in cracks, removing torn wallpaper, and sealing joints and cracks.