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Bed Bug
EDGEucation

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Confidence in
Control

Contents

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Introduction

PestWest CSI Kit with Bed Bug specimen life cycle ID disc.

In recent years, pest management companies have reported an increase in the number of Bed bug, ***Cimex lectularius***, treatments (Boase, 2001 & 2004).

Recent numerous and high-profile law suits have intensified the spotlight on Bed bug management. A number of interim reports of Bed bug resistance to technical insecticides (Boase, 2006 & 2007) have also provoked concern.

VIDEO ONLINE

For your CSI kit video, scan here or go to

www.youtube.com/watch?v=glb98afdOw8

Classification

Bed bugs belong to the Family *Cimicidae*, within the Order *Hemiptera* – the True bugs. There are thought to be 91 species of *Cimicidae*, grouped into 23 Genera. A selection of these is listed below.

Order: *Hemiptera*

Suborder: *Heteroptera*

Family: *Cimicidae*

Genus: *Cimex*

- *Cimex lectularius* (Bed bug)
- *Cimex hemipterus* (C. *rotundatus*) (Tropical Bed bug)
- *Cimex adjunctus* (Bat bug)
- *Cimex pilosellus* (Bat bug)

Genus: *Leptocimex*

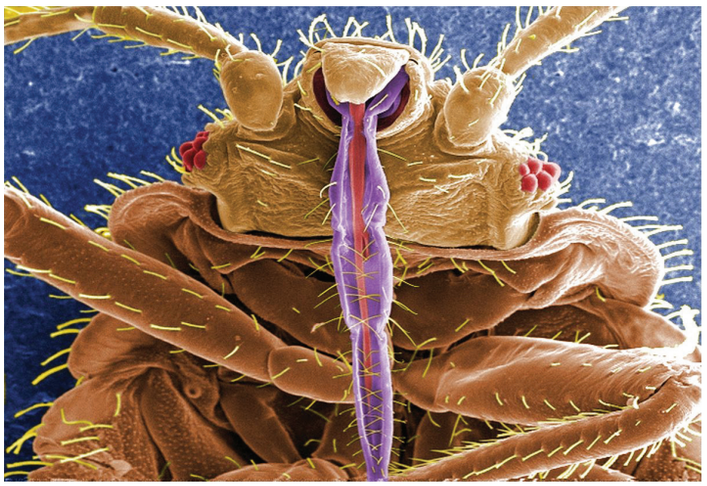
- *Leptocimex boueti* (Bat bug)

Genus: *Haematosiphon*

- *Haematosiphon inodora* (Poultry bug)

Genus: *Oeciacus*

- *Oeciacus vicarius* (Swallow bug)



This digitally-colorized scanning electron micrograph (SEM) revealed some of the ultrastructural morphology displayed on the ventral surface of a Bed bug. Image credit: CDC

Origin, history, and distribution

The evolution of the obligate hematophagous (blood-feeding) Bed bug, *Cimex lectularius*, seems to have genetically evolved from phytophagous (plant feeding) bugs. Later evolving to predatory bugs feeding upon invertebrates associated with nesting mammals or birds, and then ultimately to bugs feeding upon vertebrate hosts. Recent research suggests the Bed bug continues to evolve.

It has been hypothesized that Bed bugs made the switch from feeding upon bats to feeding upon pre-history, cave-dwelling humans.

The ecology of humans provides a monocultural host-reservoir for Bed bugs. Humans live communally within enclosed spaces, sleep at predictable times and places, possess a high body temperature, a rich blood supply, and relatively hairless, thin epidermis. Bed bugs are a global problem.

Bed bug nymphs after recent blood meal.

Adult fully replete or engorged.

Identification

Insects must be identified to species to determine correct biology and behavior.

Egg

Bed bug eggs are approximately 1mm long and 0.5 mm wide, with an egg-cap (operculum). Unhatched eggs are pearl colored and opaque pre-emergence and translucent post-emergence.

Nymph

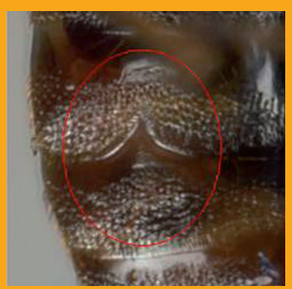
Nymphs are small versions of the adult form, with a very thin cuticle, which displays the color of partly digested blood. Bed bugs increase in size from 1.3 – 5.0 mm as they pass through 5 instars.

Adult

Adult Bed bugs are mahogany-brown, oval, dorso-ventrally flattened, wingless insects, which are approximately 5-7 mm in length and possess piercing mouthparts. When unfed, adults are pale, yellow-brown in color, but after a full blood meal, they take on a darker mahogany-brown color. Three pairs of legs are present, slender but well developed, with efficient tarsal claws for clinging onto the host during feeding.

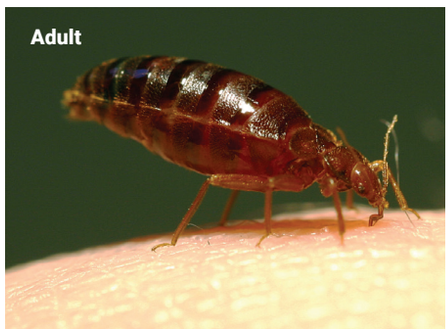
The Bed bug's head is short and broad, with a pair of prominent compound eyes (in front of which is a pair of clearly visible 4-segmented antennae). The proboscis is slender and normally tucked closely along the ventral surface of the head and prothorax. Other key points for identification include: ocelli absent and 3 - segmented tarsi.

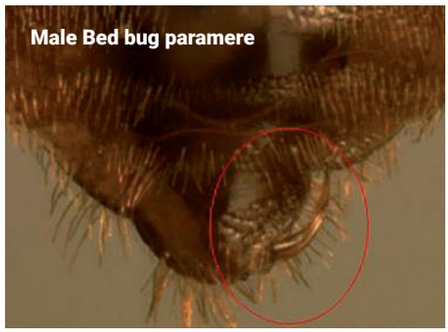
(Right) The sickle-shaped penis or paramere at the end of the males abdomen penetrates the cuticle of the female and introduces sperm. (Right) The cuticle paramere recepter (inverted v-shape) on the side of the female Bed bug.




Eggs


Nymph


Adult


Male Bed bug paramere

Evidence of Bed bug presence

Cast nymphal cuticles, eggs, straw-yellow, dark brown or black marks (excrement spots, consisting mainly of excess water and blood) and a sickly sweet-raspberry-like smell are all evidences used to identify Bed bug presence. Other indicators are customer complaints and evidence of bites.

Bed Bug specimen life cycle ID disc.

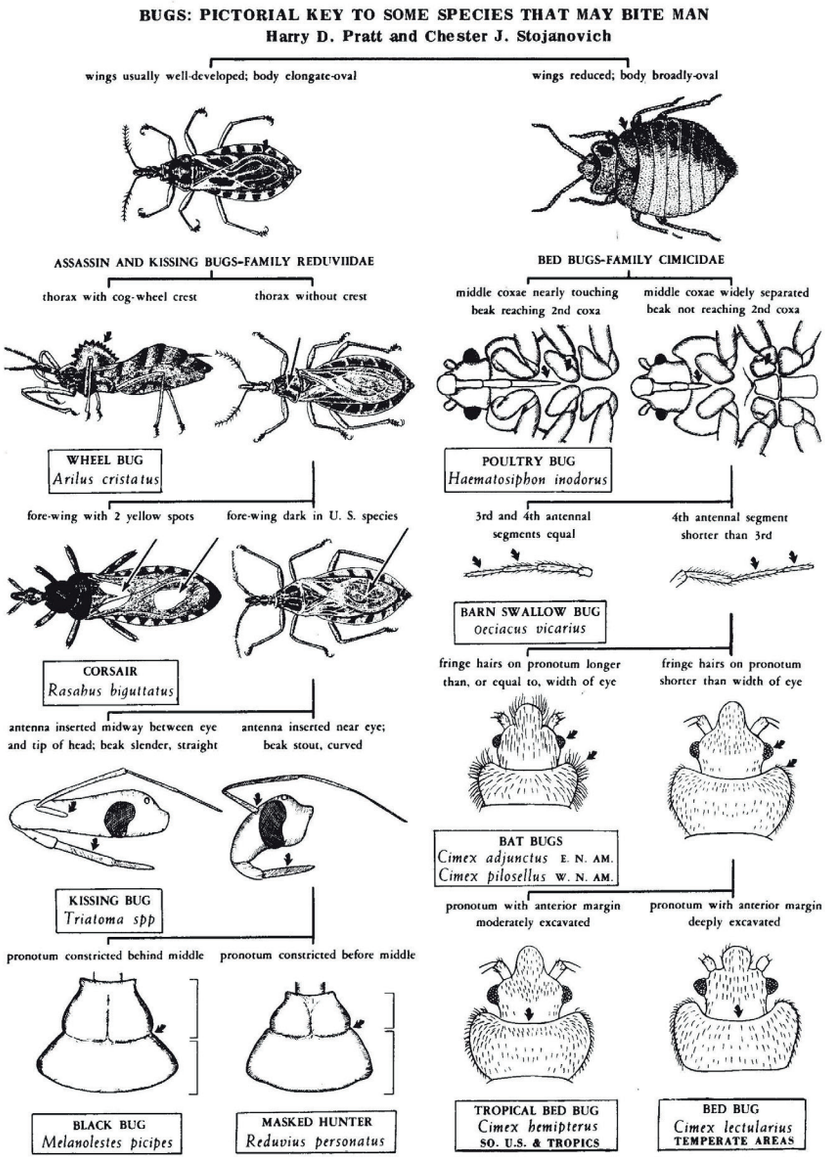


Image credit: CDC

Life cycle

Bed bugs have well defined resting sites (refugia) where bugs from all different life stages are found. The refugium is an essential part of the Bed bug life cycle as nymphs obtain internal microorganisms that are essential to their survival; some of which are also inherited from the egg. Bed bugs spend the majority of their time in these refugia, aggregated under the influence of a pheromone. Alarm pheromones are also emitted in response to stress, causing bed bugs to scatter.

Life cycle

Bed bugs exhibit incomplete or gradual metamorphosis, from egg, through 5 nymphal stages, to adult. Female Bed bugs place eggs throughout their life, an unusual behavior in non-social insects. A female generally produces ~2 to 3 eggs per day, and since they can live for many weeks, each female could produce ~400 - 500 eggs during her lifetime. Eggs are placed in and around the host, and then radiate out as populations increase. The length of time spent in the nymphal stages is temperature and available blood dependent.

The significance of this information is that the temperature dependent life cycle can be manipulated to aid management. In particular, increasing room temperature to 78^0F can stimulate eggs to hatch after 5 – 6 days and vulnerable 1st instar nymphs will quickly come into contact with fresh applications as they emerge from their many refugia such as bed frames and headboards.

Lower temperatures suggest the time to egg hatching and emergence could be elongated. Delayed hatching of eggs could give the false impression that an infestation has been eradicated, only for the Bed bugs to reappear in time (especially as the unhatched eggs could remain viable for 3 months and adults can survive for more than a year without a blood meal). If temperatures drop below 55°F, Bed bugs become unable to complete their life cycle (since most structures are heated, Bed bugs are a year-round problem).

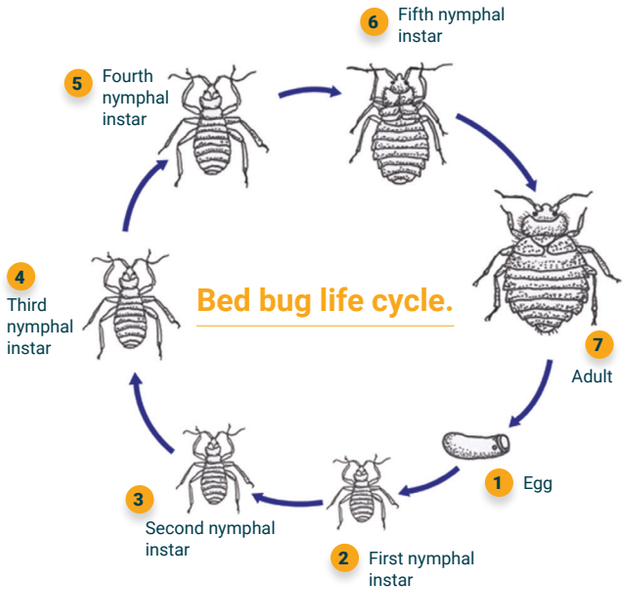


Image credit: CDC

VIDEO ONLINE

Scan the QR code to see visually informative Bed bug videos.

Public health significance

Under ideal conditions, Bed bugs can reach the adult stage in only 3 weeks.

Cimex lectularius bionomics – Eggs	
Temperature (°C °F)	Egg hatching time (days)
13°C 55.4°F	49
15°C 59°F	34
18°C 64.4°F	21
22°C 71.6°F	12
27°C 80.6°F	5 - 6

Cimex lectularius bionomics – Egg to Adult	
Temperature (°C °F)	Complete cycle (weeks)
13°C 55.4°F	Not completed
15°C 59°F	34
18°C 64.4°F	18
22°C 71.6°F	8
27°C 80.6°F	4.5

Public health significance

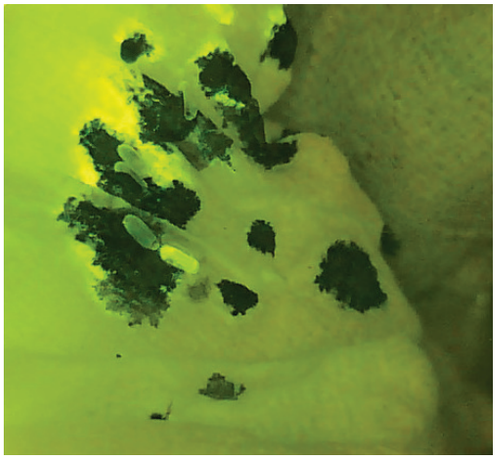
The World Heath Organization (WHO) defines health as "Health is a state of complete physical, mental, and social well-being and not merely the absence of disease and infirmity."

Bed bug infestations compromise physical, mental, and social well-being. Health effects may occur as psychological trauma, allergic reactions, and secondary infections.

Cimicosis (repetitively bitten by Bed bugs over time) may lead to a range of skin eruptions ranging from no visible effects to secondary infections.

Diagnosis involves both finding Bed bugs and the occurrence of compatible symptoms. Treatment involves the elimination of the offending insects and specific symptoms.

PestWest CSI Kit with Bed Bug specimen life cycle ID disc.



Bed bug eggs fluoresce with CSI Kit.

Bed bug bites with infections from scratching.
Image credit: Lipman Law Firm

Feeding, host location and associations

Nymph and adult Bed bugs require blood meals to develop, survive, and reproduce successfully. Bed bugs feed mainly at night when the human host is sleeping. Recent research suggests Bed bugs will feed *ad libitum*.

Bed bugs require ~12 minutes to complete a blood meal and the quantity of blood taken is ~0.0055 ml. Although Bed bugs have been found to carry blood-borne pathogens, they are not known to be vectors of pathogens. The primary medical importance is inflammation associated with bites (due to allergic reactions from Bed bug saliva).

Chronic attacks from established infestations can cause anxiety, stress, and insomnia. Development of refractory delusional parasitosis is possible as a person develops an obsession pursuant to Bed bugs.

Bed bugs are thought to locate their host through random searching, followed by orientation to heat, CO2, and host odors in perspiration and other secretions.

Dispersal

Bed bugs disperse via phoresy or within suitcases, back-packs, and second hand furniture. Additionally, as part of a reproductive strategy, female adult Bed bugs spread to even their ratio to males. Structures with highly transient occupants and low-income housing experience more infestations.

Resistance

Bed bug strains have exhibited resistance to pyrethroids. Treatment failure is generally due to a lack of understanding of Bed bug biology and behavior coupled with poor inspection and treatment methods.

If resistance is an issue, rotation of insecticides with different modes of action must be considered (also incorporating growth regulators). Be sure the product is properly labeled for Bed bugs. Non-chemical controls such as laundering, vacuuming, and extreme temperature treatments are effective aftercares.

Prof. PestWest

VIDEO ONLINE

Scan the QR code to see Prof. PestWest discuss new Bed bug research.

PestWest®
CSI Kit

Fluorescence is an optical phenomenon (photon bounce) wherein a material emits light in response to some external stimulus. Normally, the fluorescent light that is emitted is of a specific color or group of colors that is released when the material is bombarded with light in some other part of the color spectrum.

Biological materials (containing carbon and hydrogen) have a characteristic fluorescent property that facilitates identification under examination. Protein, including protein crystals, can fluoresce without any dyes or markers if it contains the appropriate amino acids in high enough concentrations and is excited with the correct wavelength of light. Two or more amino acids bonded together are called a peptide. A chain of many amino acids is referred to as a polypeptide. The complete product, either one or more chains of amino acids, is called a protein. There is unequal sharing of electrons in a peptide bond. The O and the N are negative and the H is positive. The large number of charged atoms in a polypeptide chain facilitates hydrogen bonding within the molecule, causing it to fold into a specific 3-dimensional shape. The 3-dimensional shape is important in the activity of a protein.

Proteins contain three aromatic amino acid residues (tryptophan, tyrosine, phenylalanine) which may contribute to their intrinsic fluorescence. The fluorescence of a folded protein is a mixture of the fluorescence from individual aromatic residues. Protein fluorescence is generally excited at 280 nm or at longer wavelengths, usually at 295 nm. Most of the emissions are due to excitation of tryptophan residues, with a few emissions due to tyrosine and phenylalanine. The fluorescence of the aromatic residues varies in a somewhat unpredictable manner in various proteins. Comparing to the unfolded state, the quantum yield may be either increased or decreased by the folding.

Accordingly, a folded protein can have either greater or less fluorescence than the unfolded form. The intensity of fluorescence is not very informative in itself. The magnitude of intensity can serve as a probe of perturbations of the folded state. The wavelength of the emitted light is a better indication of the environment of the fluorophore. Tryptophan residues, that are exposed to water, have maximal fluorescence at a wavelength of about 340-350 nm, whereas totally buried residues fluoresce at about 330 nm.

Lights of 400 nm or over are less likely to cause damage. Filters are required with 400 nm in order to more easily view the fluorescence. At this level, the amount of excitation causes bright light from surfaces surrounding the stain to illuminate and this illumination light needs to be blocked to reveal only the area actually fluorescing (Melles, 2002).

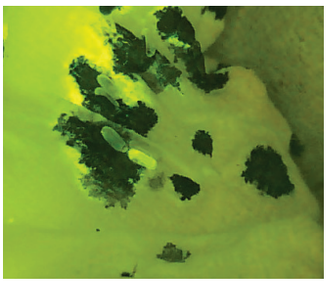
The PestWest Contrasting Specimen Inspection Kit (CSI) contains a specialty blue light lamp used in forensics in addition to the filter orange glasses, needle point forceps, specimen containers, and exclusive Bed Bug specimen life cycle ID disc.

Proteins from blood feedings and excrement, caste cuticles, and eggs will fluoresce. Using the orange filter glasses in combination with the intense 455 nm blue light adds optimal contrast, which provides maximum inspection productivity.

The PestWest CSI Kit enables the user to add a new dimension to Bed bug inspections to both intensify the inspection process and optimize time. This blue-light-emitting source is used to visualize latent signs and other physical infestation evidence. It is necessary for the examiner to wear orange glasses which are included within the Kit.

PestWest CSI Kit with Bed Bug specimen life cycle ID disc.

Bed Bug specimen life cycle ID disc.



Bed bug eggs fluoresce with CSI Kit.

Bed bug management:
tenant

- Cooperate with the landlord
- Immediately report Bed bugs
- Do not throw out belongings
- Allow access for inspections and repairs
- Treatment preparation completed
- No self treating
- If no landlord action-contact public health dept.
- Cooperate with Bed bug preventions

Image credit: Steve Thompson, BCE

Bed bug management:
housing provider

- Cooperate with residents
- Immediately make efforts to correct infestations
- Contact with pest management professional
- Allow pest management professional access
- Landlord and pest management professional educate tenants
- Lease statements

Bed bug management:
pest management professional

- Pest management professionals must have proper licenses and certifications
- Pest management professionals must have proper insurance
- Trained and certified technicians
- Prevention systems (inspection, monitoring, complaint testimony, communication, education, QA, compliance)
- Read, understand and follow pesticide product labels

Image credit: Steve Thompson, BCE

Technician safety

- Assume beds and other items are infested and act accordingly.
- Avoid leaning across or sitting on infested beds or furniture; minimize contact between clothes, equipment, and infested items.
- Bring a minimum of equipment into an infested room and place it in an open area.
- Perform an inspection of clothes and equipment before leaving an infested site.
- Launder all clothing immediately upon returning home from work. Footwear can often be heated in a dryer to kill all bed bug stages.
- Consider carrying an extra set of clothes to change into after working in a badly infested location.
- Bed bug work in residential settings involves handling other people's bed linens, dirty clothes, shoes, and other personal possessions, which exposes technicians to human pathogens, particularly blood-borne pathogens.
- Wear appropriate personal protective equipment.

Source: NPMA BMPs

Prof. PestWest

VIDEO ONLINE

Scan the QR code to see Prof. PestWest discuss technician safety.

Bed bug life cycle

Note: Bed bugs take 3-10 minutes to complete a blood feeding.

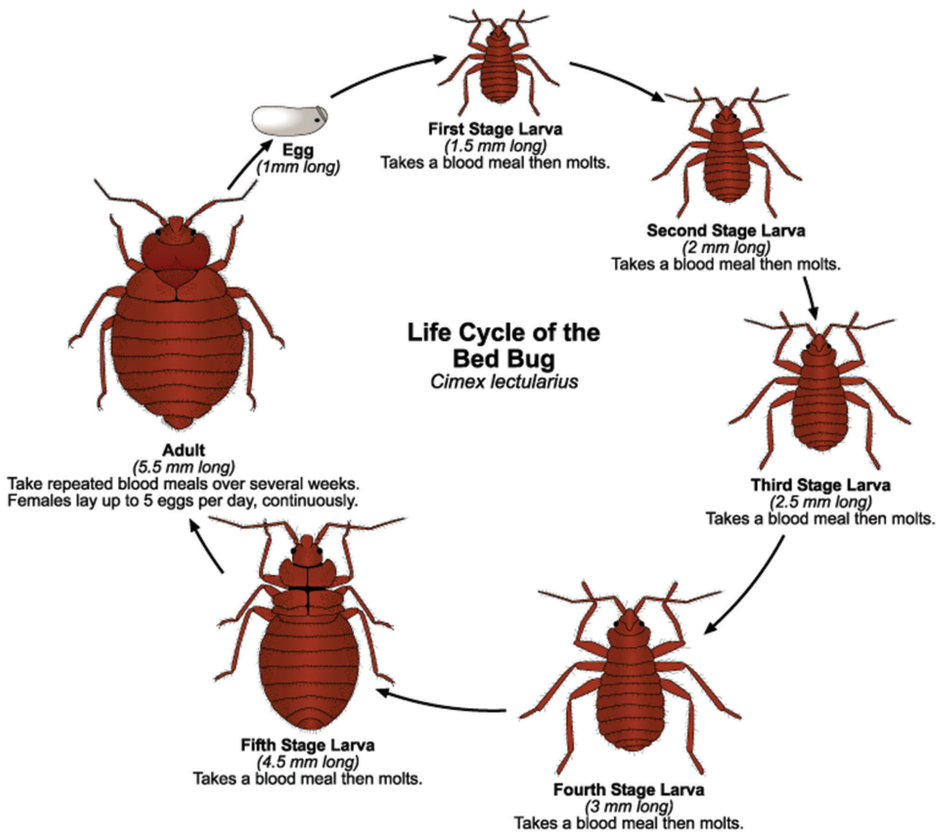


Image credit: Texas A&M Extension

Bed Bug specimen life cycle ID disc.

- Life cycle as short as 50 days
- Feed every 3-7 days
- Five nymphal life stages last 4-24 days each
- Adults live 3-12 months
- Females place 3 to 5 eggs per day, up to 500 per lifetime

Bed bug preparation checklist

Client responsibilites

- [ ] Loosen the carpet at wall/floor junction, but do not remove it from the room.
- [ ] Remove any wall-mounted items, but do not take them out of the room.
- [ ] Remove plug and switch plate covers. Turn off electrical supply to the room to avoid injury.
- [ ] Remove linen from bed and base. These should be bagged and laundered (see laundering procedures on page 21).
- [ ] Empty wardrobes and cupboards of items.
- [ ] Do not remove any items of furniture from the room. In most cases beds can be treated and do not require disposal.
- [ ] If a mattress is torn and difficult to treat, properly dispose of it (do not allow it to be taken from the refuse area). Discuss this with the pest management professional. Additionally, the mattress must be rendered unusable and sealed in a bag.

After Treatment

- [ ] Replace all items removed from walls.
- [ ] Replace carpet.
- [ ] Re-assemble room.

Signed: _____

Date: _____

Bed bug complaint log

Name					
Unit Address					
Date	Nature of Pest Complaint	Location of Complaint	Reported By	Date of Action	Reference Number

Pest management report

Name	
Address	
Date	
Reference Number	
Report Number	

Initial Visit ☐ Service Visit ☐ Follow-Up Visit ☐ Call-Back ☐

Observations/ Comments	
Recommendations/ Treatments	
Action	
Product(s)/Quantities Used	
Customer's Comments	

Customers Name: _____ Signed: _____

Technicians Name: _____ Signed: _____

Alternative management and new research

Alternative management

Vacuuming

- Vacuum cleaners with HEPA filters are recommended to prevent the spread of potentially irritating debris through the exhaust.
- Vacuum general areas of the floor and use a crack and crevice extension at wall/floor junctions.
- Vacuum mattresses and other furniture, removing cushions and turning furniture upside down.
- Place the vacuum cleaner bag in a disposable sealed bag and place in a proper waste receptacle. If possible, heat the bag to 120°F for 30 min before disposal.
- Inspect all areas for potential Bed bug refugia and vacuum if bugs are present.
- When not in use, the vacuum cleaner should be stored in a sealed bag.

Be sure to use a quality vacuum with a HEPA filter.

New research

VIDEO ONLINE

Scan the QR code to see Prof. PestWest discuss new Bed bug research.

VIDEO ONLINE

Scan the QR code to see Prof. PestWest discuss new Bed bug research.

Prof. PestWest

Other treatments and risk minimization

Cold and heat

Cold and heat treatments are commercially available to treat Bed bug infestations. Research demonstrates that Bed bugs can be managed using extreme cold treatments coupled with thorough vacuuming.

Heat treatments above 118°F (Kells, 2010) for a designated time period have proven successful in Bed bug management. Attention to detail and following the equipment manufacturers' recommendations are essential.

Steam treatment

Steam can be used successfully, depending on the quality of the steam. A direct steam application can kill all Bed bug life stages. Dry steam with less than 5% humidity, at 94°C-201.2°F, applied at a high pressure is recommended.

Risk minimization

- Remove backpacks and suitcases and inspect and/or treat thoroughly.
- After treatment, re-attach the cloth cover to the bottom of the box springs.
- Covering the mattress and box springs with an allergy and Bed bug-resistant cover may help prevent re-infestation by reducing potential refugia. Some covers will trap Bed bugs, causing them to die of starvation.
- After treatment, seal cracks and crevices.
- Repair any loose wallpaper.
- Repair any sources of moisture intrusion.

Bed Bug specimen life cycle ID disc.

Laundering procedures for Bed bug management

The table below is an excerpt from work by Richard Naylor at the University of Sheffield, UK.

Treatment Method	Temperature & Duration	Control Level
Washing machine (non-biological detergent) 3.2 kg or 7 lbs	Cool – 30°C / 86°F – 30 minute wash	Did not kill egg stages
	Hot – 60°C / 140°F – 30 minute wash	Killed all life stages
Tumble Dry 3.2 kg or 7 lbs	Cool dry – 30 minutes	Did not kill all stages
	Hot dry – 30 minutes – 40/45°C / 104/113°F	Killed all stages
Cold Soak 3.2 kg or 7 lbs	Cold water – 30 minutes	Killed adults/nymphs only
	Cold soak – 24 hours	Killed adults/nymphs only
Dry cleaning (perchloroethylene)		Killed all life stages
Freezing 2.5 kg or 5.5 lbs	2 hours at -17°C / -62.6°F (8 hours to get clothes and items to -17°C / -62.6°F, takes total 10 hours of treatment)	Killed all life stages

Notes

Notes

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Confidence in
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