# The modern bed bug and implications for hospitality and hotel bed manufacturing

Dr. Richard Naylor
Bed Bug Foundation

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## About the Bed Bug Foundation

The Bed Bug Foundation is a collective of industry professionals who's expertise lies in the detection and treatment of bed bugs. Our organization is primarily comprised of experts in the field's of pest control and scent detection, as well as an entomologist, who has been working with bed bugs for more than 20 years.

This paper has been written by Dr Richard Naylor, who is a member of the Bed Bug Foundation Senate. The Bed Bug Foundation Senate is a team of industry professionals who provide the technical expertise of the Foundation.



**Dr. Richard Naylor**

Email:
richard@bedbugfoundation.org
Phone:
+44 1291 622409

I am an Entomologist based near Chepstow on the England-Wales border. I have worked on bed bugs since 2001 when I was introduced to a small captive population belonging to Prof. Mike Siva-Jothy of the University of Sheffield, U.K. I have studied bed bugs in the context of their evolutionary history and bat origins, aspects of their unusual mating behaviour and associated immunology. For my PhD I studied bed bug ecology and dispersal behaviour using 3 meter long arenas with artificial host feeding systems.

Over the past 20 years I have continued to study bed bugs in progressively larger and more complex arenas. I now have two purpose-built test bedrooms with infra-red cameras for studying their behaviour!

I also run CimexStore Ltd. with my wife Alexia. With the help of two Technicians, Jan and Abigail, we produce insects for research and scent detection training, as well as conducting product trials for the pest management industry.



## Origin and historical abundance

Bedbugs (Cimex lectularius) belong to the family Cimicidae, which is comprised of around one hundred species of hematophagous parasites that predominantly feed on bats and cave-nesting birds.

Most blood feeding insects either fly (e.g. mosquitos, midges) or live on the host (e.g. fleas, lice), but the Cimicidae are flightless and live off the host; only visit periodically to feed. As such, they rely on hosts that consistently return to the same locations to sleep. Humans and bats are similar in this respect.

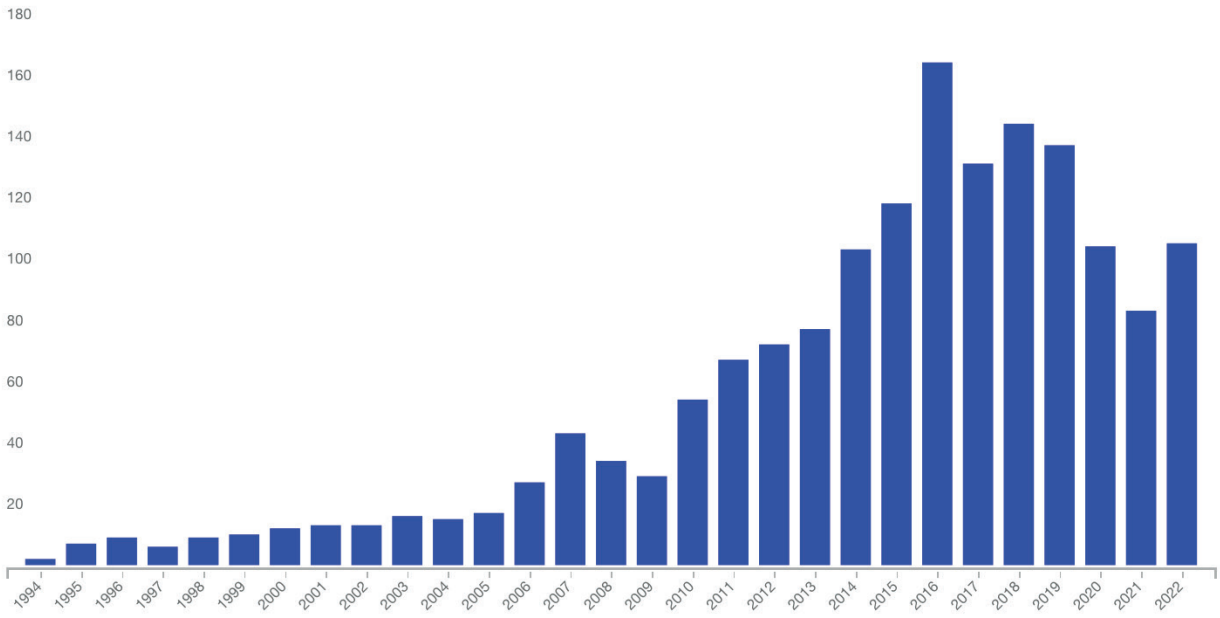
CIMICIDAE



Bedbugs made the transition to feeding on humans approximately twenty thousand years ago, probably while humans were still living in caves, alongside populations of bats. Bedbugs are one of a few members of the Cimicidae that now parasitise humans. These species also still occur on their ancestral bat hosts.

There are reports from the 1930s that bedbugs once infested virtually every house in London. The introduction of DDT and other synthetic insecticides radically improved the situation and between the 1960s and 1990s bedbugs were hardly seen. Towards the end of the 1990s, bedbug populations began increasing synchronously all over the world.

Good sources of data on current bedbug abundance is difficult to find. Treatment data from pest managers is always skewed by their market share. If the company grows over time, it may undertake more bedbug jobs, which masks real trends.




This data comes from The Swiss Pest Advisory Service in Zurich. It is based on enquiries to a free public information service and is therefore not affected by market share. Based on this, bedbugs were increasing quite rapidly between 2005 and 2018, but they then declined sharply. This is likely impact of the Covid19, which shut down the hospitality sector and restricted the movement of people. It also gave hotels a window of opportunity to tackle the problems they had.

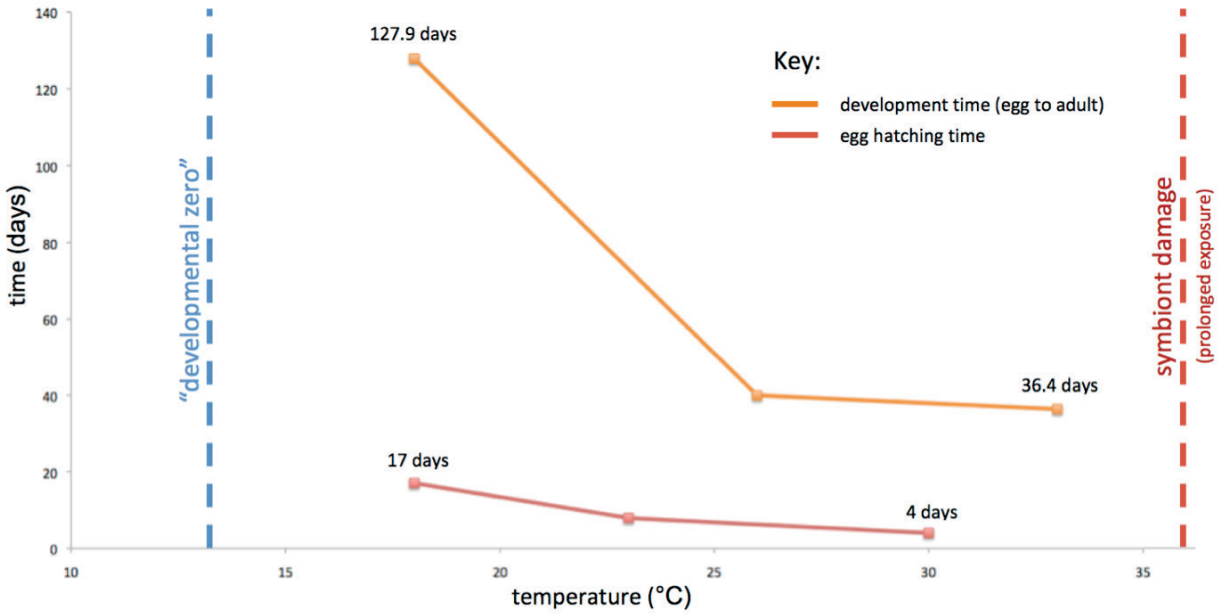
In the years following Covid19, many pest controllers reported having very little bedbug work. But now it seems that bedbug numbers are recovering, although potentially still well below where they were in 2018.

## Factors affecting the global success of bedbugs

Human population density - The closer people live together, the more easily bedbugs spread. The global population of bedbugs consequently reflects that of humans, with the majority being found in cities, and especially in low-income housing and hospitality, where people sleep relatively close together.

Movement of people - Bedbugs spread on the clothes and belongings of people. So areas with high movement of people tend to have more exposure to bedbugs. Hotels with an average customer stay of 1.2 nights night have worse problems with bedbugs than hotels with a minimum 3 night stay. Hostels for back packers tend to be particularly affected by bedbugs. Guests sleep with their bags on or close to the bed, rucksacks have many pockets and zips and other features that make it easy for bedbugs to find a suitable hiding place.

Temperature - the warmer bedbugs are, the more frequently they feed and the more rapidly they reproduce. At 13oC bedbugs are completely inactive; they don't feed and eggs don't hatch. At 18oC their generation time is around 3 months. At 26oC their generation time is around 6 weeks. In temperate climates, central heating allows bedbugs to remain active throughout the year, where previously their activity would have been limited to the summer months.




*Effect of temperature on egg hatching time and total development time. At temperatures below 13°C all development ceases. At temperatures above 36°C (prolonged exposure) mortality occurs due to symbiont damage.*





## Suitability of the host sleeping environment for bedbugs

To establish an infestation, bedbugs need regular access to a host and a suitable crevice to hide in, usually within a meter of where they feed. Bedbugs can't climb smooth surfaces, such as glass, plastic and metal, and so tend to seek out natural fibrous materials like wood, paper and fabrics. Some sleeping areas are therefore more suitable for bedbugs than others.

Metal frame beds are less frequently infested by bedbugs because they are difficult to access and offer fewer suitable hiding places. Divan beds are particularly suitable for bedbugs because they are easily accessible and have large internal voids, where the bugs can hide undetected.







Bedbugs can't fly or jump, but they are good at walking. They can easily walk down a corridor and squeeze under a door. They can survive for up to 18 months without food, so they have plenty of time to move around a building in search of a new host. Hungry bedbugs forage at night. They detect carbon dioxide and are attracted by body heat. Bedbugs in a room can detect a person in a bed and will search actively for a way up.

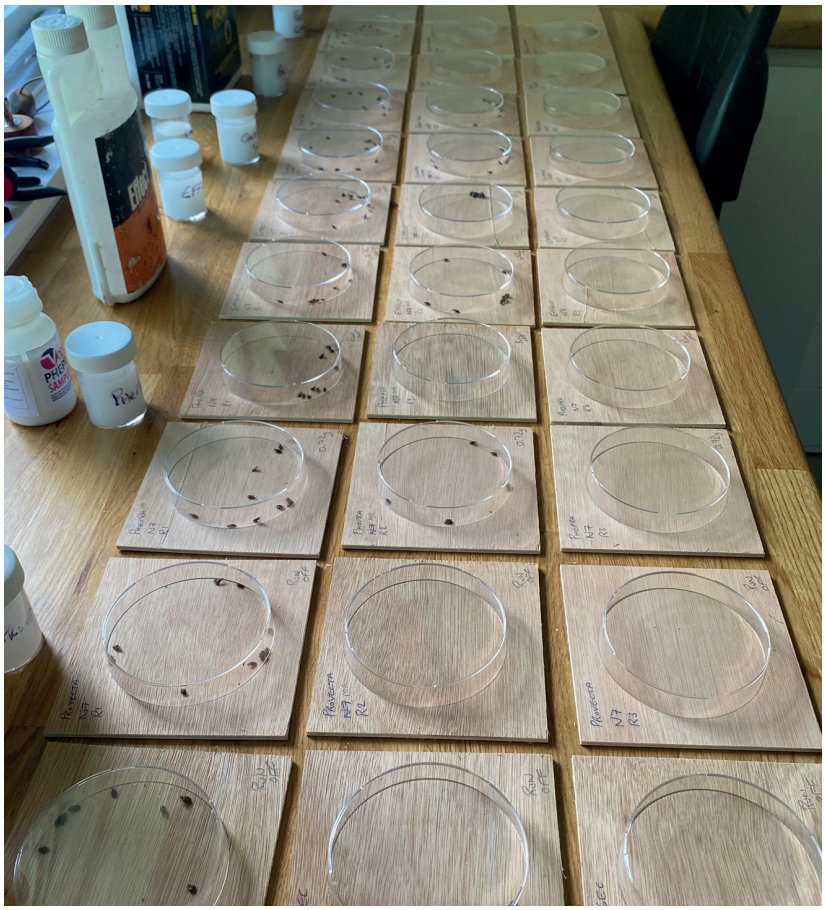
After feeding, they search for somewhere to hide, ideally as close as possible to the feeding site. Bedbugs aggregate, using pheromones to locate each other. These pheromones are deposited in their hiding places, helping them to find their way back after feeding.

In a domestic environment bedbugs can often be found hiding in countersunk screw holes and around the ends of bed slats, as well as around any features on the mattress, like the piping and grab handles. The areas where they hide become peppered with black faecal material.

In a highly disturbed environment, such as hotels, where sheets are changed almost daily, bedbugs tend to be found deeper with the structure of the bed or behind wall mounted headboards, where they are particularly difficult to find.

## Insecticide resistance

Over recent decades the range of chemical insecticides available for bedbug control has gradually reduced. Today almost all chemical insecticides registered for bedbug control are pyrethroids. Pyrethroids interact with the sodium iron channels in the insect's neurones, causing paralysis and death. Widespread use of pyrethroids has already selected for high levels of insecticide resistance and a range of different resistance mechanisms, including the production of detoxifying enzymes, thickening of the cuticle and changes to the target site on their neurons, preventing the insecticide from binding. In practical terms, bedbugs that are directly sprayed with liquid insecticides are normally killed, but dry residues are no longer effective. Even continuous exposure for days or weeks to professional strength insecticides often has no visible effect on adults, nymphs or eggs of modern bedbug populations.



Similarly, the use of pyrethroid impregnated fabrics has been shown to be ineffective for bedbug management (Doggett et al. 2022). It also ensures that bedbug infestations are under constant selection for high levels of resistance to these compounds, meaning that chemical treatments are less effective in the event of an outbreak.

Professional pest managers are subject to Control of Substances Hazardous to Health (COSHH) regulations, which require them to undertake a risk assessment identify the target pest and then considering all non-chemical alternatives before applying an insecticide. Under these regulations it is difficult to justify the application of any insecticide as a preventative measure against bedbugs.

## Prevention

### Bed design

Simple bed designs are much easier to check for bedbugs. Beds with an abundance of pleated fabric and large inaccessible voids provide bedbugs with numerous potential hiding opportunities that are very difficult and time consuming to check and treat.

### Shiny feet or legs

Prevent bedbugs from gaining access to the bed. Bedbugs primarily move around at night. They are attracted by body heat and carbon-dioxide from exhaled breath. Isolating the bed from the room prevents infestation, because bedbugs that can't feed, can't reproduce.

### Encasements

Mattress and bed base encasements reduce the number of places where bedbugs can hide.

### Room design

In the hospitality sector, most bedbugs arrive in the guests' luggage. Providing luggage racks, encourages guests to keep their bags off the floor and away from the bed, making it more difficult for bedbugs to transfer to and from the guests' possessions.

### Laundry handling

Bundling bedding into large trolley cages has the potential to disperse bedbugs throughout the building. Soluble laundry bags can be used to isolate bedding before it leaves the room.





## Early detection

### Staff training

Bedbugs leave spots on the bedding. This is often one of the first indicators of an infestation. Training staff to recognise these marks can help to detect infestations before they have time to spread.

### Scent detection dogs

Bedbug detection dog services are now available in most parts of the country UK. They are also widely used across Western Europe and the US. Dogs can be used for routine screening or in response to a complaint. They can be helpful for identifying the spread of an infestation through a building and confirming that a remediation has been successful. Dogs have the ability to sniff inside hollow bed bases and behind headboards, where visual inspection by a human are often difficult. Most dog teams can search a hotel room within a few minutes, with little or no disturbance to the room.

### Traps and monitors

The efficacy of any of these devices is difficult to prove. Most traps are designed to sit on the floor under the bed, but bedbugs are more commonly encountered hiding within the bed structure.

### Digital remote monitoring

There are (almost) three bedbug remote monitoring systems on the market in the UK. Valpas from Finland have a monitor that replaces the bed legs (where bed design allows). Spotta from the UK have a remote-monitoring pitfall trap for bedbugs, which tucks under the edge of the mattress. Russell IPM also from the UK have a monitor currently undergoing field trials, which attaches to the bed base. All three systems communicate via a LoRa networks, alerting the pest manager via a phone app.



*Valpas*




*Spotta - Bed Pod*



*Russell IPM - iBug*

# Treatment

### Chemical insecticide sprays

These have been the mainstay of the insect pest control industry for decades, and are often still the first resort for pest managers. But growing problems with resistance and tightening legislation around the use of insecticides is forcing the pest management industry to explore other options.

### Structural heat treatment

Heat treatments are increasingly used for bedbug control, especially where infestations have spread through multiple rooms of a building. Some systems use diesel generators to heat water, which is pipped around the building to heat exchangers in each of the rooms. Smaller systems run off electricity. If the building's power supply is not sufficient for the current demands of the heaters, generators can be hired for this purpose. Structural heat treatments are generally considered to be a premium option and are therefore reserved for more established infestations affecting multiple rooms.

### Bubble heat treatment

Smaller scale "bubble" heat treatments use an insulated pop-up tent, similar to a small pop-up gazebo. The bed and other furniture are stacked inside and sealed in for several hours as they are heated to a minimum of 50oC. The energy requirement of this system is much more efficient, because it heats a much smaller volume. The system can be just as effective as the structural heat treatment, but only if the bugs have not spread into the fabric of the building.

### Non-chemical sprays

Many non-chemical sprays are effective at controlling bedbugs if the bedbugs are hit directly. Commercially available sprays may include plant extracts, cellulose polymers and or surfactants. They generally work by covering the insects spiracles, causing suffocation. Although bedbugs are susceptible to these products when sprayed directly, the products offer no lasting protection as dry residues.

### Steam

Some steamers have been developed specifically for bedbug control. Like the non-chemical sprays they offer no residual protection. The pest managers must ensure that the bed structure is treated very carefully and methodically, firing steam into every potential hiding place. The system is effective, a long as the technician is sufficiently thorough.

### Fungal spores

There is currently one commercially available product, Aprehend RTU, that uses the spores of entomopathogenic fungi (Beauveria bassiana) to control bedbugs. Fungal spores are applied as a spray. These are picked up on the cuticle of the bedbug and ultimately kill it. The manufacturer s claim that the spray provides residual protection for up to 3 months.

### Desiccant dusts

Diatomaceous earth (DE) is a silica-rich mineral that is mined out of the ground and milled down. It has the appearance of talcum powder and is effective at controlling many types of insects by desiccation. DE is does offer lasting residual protection against bedbugs, but it is messy and therefore its use tends to be restricted to areas where it cannot be seen, such as behind electrical outlets and inside headboards and bed bases, where bedbugs like to hide.

Amorphous silica dioxide (ASD) is a synthetic alternative to DE. ASD tends to be faster acting, although none are currently registered for professional use in the UK.

## References

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richard@bedbugfoundation.org
+44(0)1291 622409 / +44(0) 7980 614122
www.bedbugfoundation.org

Bed Bug Foundation
Prior's Loft
Coleford Road
Tidenham
Chepstow
Monmouthshire
NP16 7JD