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CONTENTS

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Bed bugs: Don't panic!



The thrips of the Maltese Islands



Climate change and insects: We don't know enough

- 1 Editorial
- 2 Letter from the President
- 3 Correspondence
- 4 Article: Bed bugs: Don't panic!
- 10 Article: The thrips of the Maltese Islands
- 14 Article: Climate change and insects: We don't know enough
- 18 Article: Those jazzy striped butterfly antennae: Why do some species have them and others don't?
- 22 Featured Insect: The European Earwig, *Forficula auricularia* L.
- 23 Insects in the News
- 24 Society News
- 25 Journals and Library
- 26 Grant Reports
- 27 Meetings
- 37 Honorary Fellow Interview – Stuart Reynolds
- 43 Outreach
- 49 Insect Identification Service
- 54 RES Scholars
- 56 Reviews
Events



Those jazzy striped butterfly antennae: Why do some species have them and others don't?

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Cover Picture: Female dance fly (probably *Empis livida*) photographed by Colin Lamb in Oxfordshire, England.

Back cover: Female Meadow Grasshopper (*Pseudochorthippus parallelus*) photographed by Jeni Fulton Price near Exeter, England. Both photographs were submitted to the Society's Insect Identification Service, see article on pages 49–53.

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Bed bugs: Don't panic!

Bed bugs (Cimidae) are amongst the strangest of insects. Almost everyone has heard of them and yet very few people know anything about them. They are universally feared but they can tell us a lot about insect biology, and even about human behaviour. I must admit, until 2014 when I started working for Prof. Mike Siva-Jothy at the University of Sheffield, I had little idea what a bed bug was. All I knew was that Mike liked to feed them on his legs. Fast forward nearly 10 years: Mike is enjoying retirement, and I am feeding the bed bugs on my legs (Fig. 1). During this time, I have been fortunate to study almost all aspects of their biology and behaviour, from their immune system to their distribution across cities around the world. In this article, I'm going to look at the origins of our fear of bed bugs, their 'resurgence' and what we should do about them.

Like all members of the Cimicidae, *Cimex lectularius* (Box 1) feeds exclusively on blood and, although humans are their preferred host, they will feed on other mammals and birds. As with most Hemiptera, development consists of three life stages – egg, nymph and adult (Fig. 2). Each stage requires a blood meal.

Bed bugs spend large amounts of time in refuges and are thus very hard to detect, especially in the early phases of an infestation, and while in their refuge (called a harbourage), they are inaccessible to most chemical control agents and application methods. The most common places to find their harbourages are cracks or crevices in or around beds or sofas; anywhere you spend long periods of time stationary (Fig. 3).

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Figure 1. Feeding bed bugs on my leg. The tube has a mesh top that the insects can fit their mouthparts through.

There are very limited empirical data on their natural behaviour in and around harbourages, so most of what is known about leaving and returning to harbourages comes from laboratory studies. They have very few natural predators, most of which are often classed as household pests themselves, such as ants and cockroaches. I was asked by a reporter for *National Geographic* what would happen if bed bugs disappeared overnight. Unlike other haematophagous species such as mosquitos, which have an important role within ecosystems, such as a food source (Fang, 2010), bed bugs do not have

such a role. If they were to disappear overnight, nothing would happen to the natural world, but it would have lost one of its most fascinating species.

Fear of bed bugs

Humans seem to have an irrational fear of bed bugs. I am confident in saying that the majority of people in the Western World fear bed bugs more than other blood-sucking insects such as mosquitos. This is surprising given that mosquitos have been termed by the Centres for Disease Control and Prevention as "the world's deadliest animal" (CDC, 2023). Unlike mosquitos, bed

Box 1: What is a bed bug?

Bed bug (often mistakenly 'bedbug' – Box 2) usually refers to either of two species within the family Cimicidae (order – Hemiptera) which feed almost exclusively on humans. The most common in Europe and North America is *Cimex lectularius* (a) and the less common *Cimex hemipterus* (b) which can be found in the tropics. I will focus most of this article on *C. lectularius* which I will refer to as 'bed bugs'; but it is worth noting that *C. hemipterus* is no longer restricted to the tropics and is now established in low-level populations within Europe (Balvin *et al.*, 2021), possibly due to our warming climate.

a



b



Adult female *Cimex lectularius* (a) and *C. hemipterus* (b). Adapted from Balvin *et al.*, 2021.

Box 2: Bed bug or bedbug?

I may be preaching to the converted here, but I wanted to mention the two versions of the name 'bed bug'. In most media articles (and some published papers) 'bedbug' is used. Convention has it that where names have two parts and one of them is the systematically correct group name, as is the case here, the group name should be a separate word. If, however, the group name is not systematically correct, it should be combined into a single word – e.g., Citrus Whitefly.

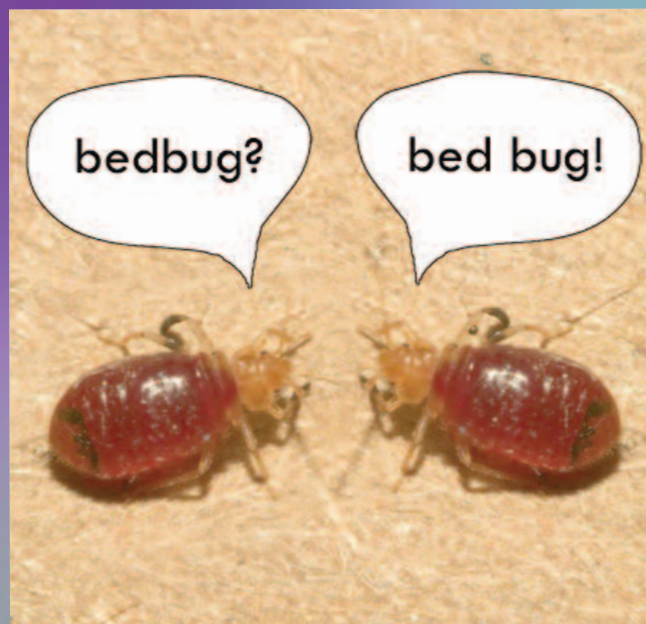


Image credit: Unknown author – <https://citybugs.tamu.edu/files/2011/03/bed-bug-cartoon2.jpg>

bugs are not known to vector any diseases, and death from a bed bug bite is very unlikely, although some extreme allergic reactions have been reported (Doggett *et al.*, 2012). Bed bugs usually feed on humans when sleeping, very similar to mosquitos, so the idea of something biting while you sleep probably isn't solely driving this fear. Where then does this fear come from?

One possible source of fear may be linked to the long history we share with bed bugs and how they have become embedded in our culture. The phrase "*night night, sleep tight, don't let the bed bugs bite*" has been recited by many parents to their children for centuries. In the 17th Century, bed bugs were not seen as a major concern and being bitten in bed was just a fact of life (Sarasoehn, 2013).

This all started to change during the 'Age of Enlightenment' and the start of the industrial revolution with some of the first records of professional bed bug controllers, *Tiffin and Sons*, appearing in 1730 (Usinger, 1966). At this time there was also the emerging 'middle class' who were putting a much greater emphasis on sleep, with many households spending a quarter of their income (Ekirch, 2001) on beds with feather mattresses, heavy curtains, and canopies – perfect homes for bed bugs. Despite attempts to control bed bugs by 'professionals' or even a wide range of home remedies, bed bugs were still very common in people's homes until the 20th Century.

After the first world war the bed bug's days were limited. Chemicals which were used in the war were repurposed for pest control, the most prominent being hydrogen cyanide (Biehler, 2013). This is, unsurprisingly, very dangerous to all living animals, including humans, and could only be used by (very expensive) highly trained professionals. Further, it could only safely treat detached properties due to the risk of accidentally poisoning adjoining properties. Therefore, only the middle and upper classes could afford to rid themselves of bed bugs, whereas the poor, in their high-density accommodation could not. Bed bugs were becoming a symbol of being poor and 'unclean'.

This all changed with the appearance of DDT (dichloro-diphenyl-trichloroethane) in the

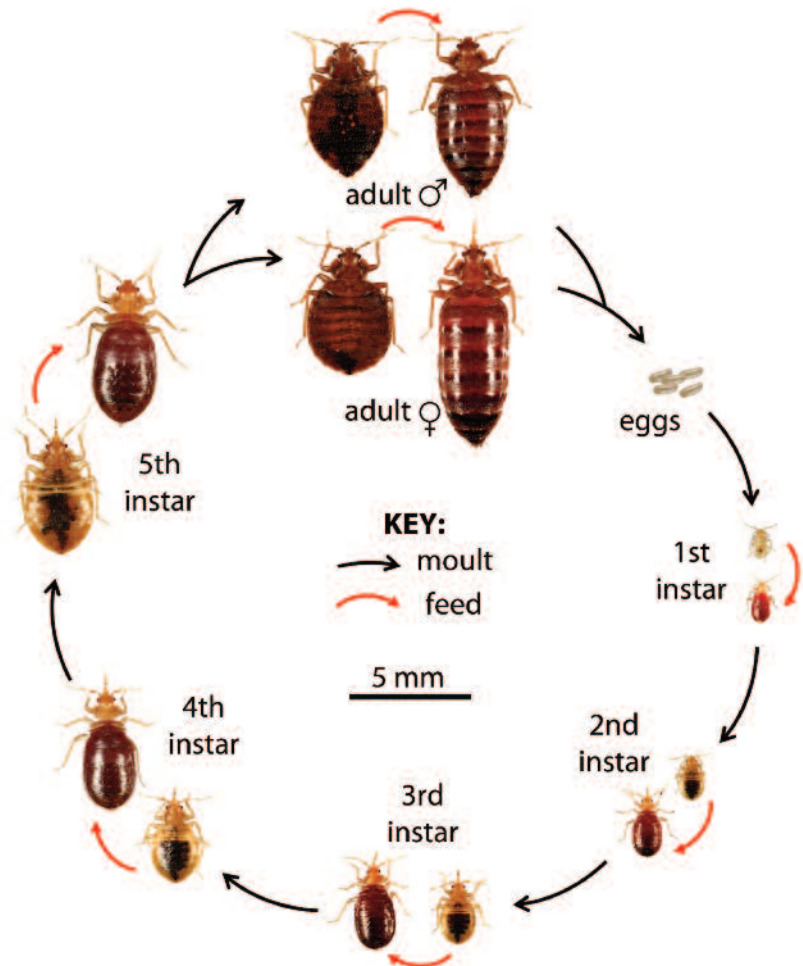


Figure 2. Schematic of bed bug life cycle. Image courtesy of Dr Richard Naylor, The Bed Bug Foundation.



Figure 3. A large bed bug aggregation found under the lining of a box-spring bed. Photo courtesy of Dr Richard Naylor, The Bed Bug Foundation.

1940s. This could be used in high density housing and did not require professionals to apply it (Biehler, 2013). It was so effective that, by the 1950s, bed bugs had been almost entirely eradicated from the Western World (Doggett *et al.*, 2012). Bed bugs became a myth, with the younger generation having never seen one, or knowing what to do if they had an infestation.

Lack of knowledge, therefore, could be a major contributor to the fear associated with bed bug infestations (Goddard and de Shazo, 2012). Fear of the unknown is

a fundamental human trait, one which was clearly adaptive for us in our evolutionary past (Brosschot *et al.*, 2016) and remains with us today. One of the side effects of this fear of the unknown is the instinctive need to find the 'truth', even if that 'truth' is not factually correct (Raub, 2021). The urgency to discover the truth can sell stories, so media frenzies often follow.

Media frenzies and misinformation

The media have played a significant role in shaping public perception of bed bugs. Sensationalised

headlines and fear-mongering stories can create panic, which leads to irrational responses. Last year's reports on the bed bug 'outbreak' in Paris is one of a long line of such media frenzies. However, the Paris example is slightly different from previous media frenzies because it was fuelled by viral videos on social media. As one of the few scientists studying bed bugs, I received many calls and emails to give my opinion on the outbreak in Paris.

Fortunately, this was not my first rodeo, having experienced a similar



Figure 4. a) AI-generated image of a bed bug (Stefano, Adobe Stock). b) Bed bug feeding (Dr Richard Naylor, The Bed Bug Foundation).

media frenzy when I published a paper about bed bug aggregation behaviour towards dirty laundry (Hentley *et al.*, 2017). The questions that were asked varied greatly depending on the media outlet; for example, BBC Radio 4 and The World Service wanted to know the facts behind bed bug population cycles and what we can do about them, whereas other, less academic, media outlets wanted to know “if we should be hosing down the French with insecticides as they get off the EuroStar”. I have found the trick is to stick to the science and avoid jargon. But why do these media frenzies happen and why are they nearly always negative?

Evidence suggests that, over our evolution, seeking out negative information was adaptive. A study by Davis and McLeod (2003) reviewed front-page news stories over the last 300 years and found that very little has changed in the type of news being presented. Many of the themes the authors identified could be linked to adaptive behavioural traits seen in other primates, such as altruism, cheat detection, reputation (or rank), and treatment of offspring. In some ways we are hard-wired to seek out these negative stories and if this kind of story sells, it will proliferate. The stigma associated with bed bugs means that they already have all the traits of a good news story, which may be why we see these periodical media frenzies associated with them.

Public understanding of bed bugs

The theme of our news may not have changed over the last 300 years, but the way we access news has. In 2016, it was found that 60% of adults in the USA were getting their news from social media (Gottfried & Shearer, 2016), increasing to 91% in 2021 (Walker & Matsa, 2021). Social media has increased the efficiency and spread of news transmission, but much of the content has little or no meaningful fact checking or editorial judgement, leading to the rise of ‘fake news’. Another study of adults in the USA suggested that people who get their news from social media are less engaged and less knowledgeable than people who use a combination of news sources (Mitchell *et al.*, 2020). This has been seen in the public’s understanding of bed bugs, where Seidel & Reinhardt (2013) found that researching bed bugs on the internet, TV or printed media generally resulted in a



Figure 5. Bed bug bites on human skin. Photo courtesy of Dr Richard Naylor, The Bed Bug Foundation.

reduction in recognition rates of bed bugs. The rise of artificial intelligence could exacerbate this. For example, during the Paris bed bug media frenzy, many popular UK media outlets were using images of bed bugs (e.g., Fig. 4) generated by AI. These images are clearly incorrect. I’m not even sure if the example given here looks like a known insect species, more of a mix of several. This misinformation could add to the poor public understanding surrounding bed bugs.

If you are interested in learning more about role of AI in entomology, the Data and Electronics & Computing SIGs’ theme for their next meeting on 3rd July is AI in Entomology.

Public understanding of bed bugs in Europe is fairly limited. For example, only 13% of residents in four German cities were able to identify a live bed bug (Seidel & Reinhardt, 2013) and only 10% of UK residents could do the same (Reinhardt *et al.*, 2008). In a survey of 600 Indonesian residents, 74% could identify a bed bug (Meisyara *et al.*, 2023), as well as 91% of the residents in an Ethiopian village (Karunamoorthi, 2015), and most from a survey of 900 people in Kenya (Mbuta *et al.*, 2022). Variation in the ability to identify bed bugs

could be linked to their prevalence, or to cultural awareness.

With the public clearly having issues identifying bed bugs, their bites are often used as a proxy for an encounter. There are many reports of the public presenting such bites and medical professionals confirming they are bed bug bites (Fig. 5). Even the UK National Health Service provides guidance on identifying bed bug bites. This is surprising given that most scientific papers advise that a bed bug bite is very difficult to distinguish from other insect bites (Doggett *et al.*, 2012; Leung *et al.*, 2024). This is another source of potential false information which could be fuelling the uncertainty and panic around bed bugs.

The Paris outbreak

Nearly every published paper about bed bugs opens with a statement about their increase or resurgence, supported by studies from across the world including China (Wang *et al.*, 2013), USA (Potter, 2011) and Australia (Doggett *et al.*, 2011). One of the key drivers of bed bug dispersal is human travel, therefore it is not surprising that France, as the world’s most popular tourist destination (World Tourism Organization, 2019), has seen a resurgence of bed bugs. The Centre National Francais D’Expertise Sur Les Vecteurs (CNEV) in

France highlighted that bed bugs were a public health concern. Indeed, they have been reported across the country (Akhoundi *et al.*, 2015; Jourdain *et al.*, 2016), including in Paris (Candy *et al.*, 2018; Chebbah *et al.*, 2021). Finding data about the number of bed bug cases on public transport in Paris for 2023 (or any year) is very difficult. France's regional rail operator, SNCF, reported 37 sightings up to October 2023 and 10 were reported for the same period by the Paris transport operators, RATP (O'Malley & Feighery, 2023). This is a much lower level than social media videos and news reports suggest. Unfortunately, I was unable to find any other data, which is a common problem when trying to understand bed bug population dynamics. There is no central database where occurrence data are reliably recorded. Most of the public would go to the private sector for pest control, but data from this sector are often classed as commercially sensitive and not usually shared, even for scientific research purposes. To understand outbreaks, we need to rethink our research priorities.

Prioritising understanding over eradication

The recent media spotlight on bed bugs has clearly demonstrated that they are a significant problem and, despite our best efforts, are increasing globally. The focus of the scientific and professional community has nearly always been eradication. Like many pest insect species, research into bed bug control has focused mainly on developing new chemical pesticides. In the past, DDT was clearly very effective at almost eradicating them and many have blamed the banning of its use for the current bed bug resurgence; however, this is a misconception. Evidence from as early as the 1950s suggests that bed bugs were already becoming resistant to DDT (Busvine, 1958), which wasn't banned in the UK until 1986, and 1972 in the USA. As we have seen in countless other insect species, pesticide resistance is usually very quick to spread and most bed bugs are, at least partially, resistant to modern pesticides (Lewis *et al.*, 2023).

To address the bed bug problem effectively, we need to shift our focus from eradication to understanding and management. There remain some fundamental questions about their biology and

ecology. One of the biggest unknowns is the mechanism by which they disperse. To answer broad ecological questions, we need comprehensive data about their occurrence at fine spatial scales. Unfortunately, these data are hard to come by, not only because the location of confirmed infestations is usually commercially sensitive, but also because data from public bodies are usually incomplete and don't account for the aforementioned private sector. Nonetheless, data from public bodies can give some insight. For example, my own work using data collected from local authorities demonstrated that the number of confirmed infestations follows a clear seasonal cycle that peaks in summer, something supported by studies from Philadelphia (Mabud *et al.*, 2014), New York (Hacker *et al.*, 2022) and China (Wang *et al.*, 2015). The summer peak is unlikely to be linked to temperature because bed bugs live in heated/air-conditioned homes. The peak correlates with the peak in human travel. With humans being the vector for this flightless insect, it would strongly suggest (although never proven!) that our behaviour is the most important driver of the bed bug resurgence.

So, our best hope for controlling bed bugs might be altering our behaviour or, at the very least, educating the public about what bed bugs are, how to avoid getting them and what to do if they are found. Evidence from New York suggests this kind of approach might work. After the widely covered New York bed bug outbreak in 2010 where they were seen in cinemas, the metro and in schools, the city council embarked on a public education campaign, and a disclosure policy where landlords were obligated to notify tenants of infestations. This led to compulsory quarantine, where infested units were taken off the market while the landlord dealt with the problem. They also introduced a priority number to call for information if bed bugs were found. As a result, the number of reported bed bug cases is still declining in the city (Hacker *et al.*, 2022). This is very promising and something that should be trialled in other cities and countries. Another side effect of increasing public understanding of bed bugs might be to reduce the fear associated with them, reducing the chance of media frenzies which can spread false information.

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