

## BEDBUGS – BACK FROM THE BRINK

Clive Boase of the Pest Management Consultancy in the UK, reviews the current bedbug outbreak, and raises questions about our response to such problems

### The current problem

Most people involved in urban pest control in developed countries 10 years ago would have agreed that bedbugs were almost consigned to history. Around 5 years ago, however, something changed, with the result that bedbugs are back in force. Bedbugs now cause serious concern, both to those controlling the problems, and especially to those on the receiving end.

The outbreak is a classic urban pest management problem, with a wide range of interested parties, such as the public, the pesticide and pest control industries, the hospitality industry, housing organisations, the media, the health service and local government. The outbreak also raises issues such as our ability to deal with such outbreaks on both a technical level, and a broader administrative level. There must also be questions of how we can support the necessary research into pests that are of intense but sporadic impact.

At the same time, those involved with the problem are extremely relieved that bedbugs, despite their multiple blood-feeding habits, do not appear to transmit any human pathogens, or we may have been looking at a far more serious situation.

### Background on biting bugs

Although most true bugs (Order: Hemiptera) feed on plant fluids, a few groups of specialised bugs have lost the phytophagous habit, and instead now feed on vertebrates. The two main vertebrate-feeding Families are the Reduviidae which are responsible for the transmission of Chagas disease in Central and South America, and the Cimicidae, or bedbugs. The main bedbug species throughout temperate regions is *Cimex lectularius* (Figure 1), whilst in the tropics it is largely replaced by the very similar *C. hemipterus*. In addition to these two species, certain closely related bird bugs also occasionally enter buildings and bite humans.

### Infestation profile

Bedbugs are typically chestnut brown, dorso-ventrally flattened, with the adult measuring up to c. 5 mm across. During her life, the adult female lays around 350 eggs, attaching them singly yet firmly to the surface of the harbourage and surrounding area, where the empty case will remain long after hatching. After a period of incubation (Table 1) the eggs hatch into a small (ca. 1.3 mm) nymph,



Figure 1. Adult bedbug (*Cimex lectularius*). Size up to 5mm across.

Table 1. Bedbug development time

Temperature	Incubation period	Complete life cycle	Life span
18°C	20 days	125 days	ca. 12 months
25°C	7 days	46 days	ca. 5 months

which goes through 4 further instars before moulting to the adult. Each nymphal stage requires a single blood feed before moulting to the next stage.

In heated premises with adequate food supply, bedbug reproduction will continue throughout the year, and a small starting population has the potential to develop into several thousand individuals within a year (Johnson, 1941). Even in the absence of a blood source, individual bedbugs have been shown to survive a year or more (Bacot, 1914), which enables infestations to persist in empty properties, or on items of furniture in storage.

Bedbugs spend almost all their time concealed in harbourages, such as around the seams on mattresses, in bed-frames, behind headboards, behind skirting boards, in furniture, inside electrical fittings, behind pictures and coving, in curtains, under fitted carpets and in wall voids. Only very rarely are they found on clothing or on the person. Both private households, staff accommodation, hotels, and other temporary accommodation are typically infested.

Local dispersion of infestations can occur through the



Figure 2. Typical bedbug bites.

active movement of individual bugs. In one building examined by the author, infestations were shown to have spread from room to adjoining room, at a rate of about 7 weeks per room, with dispersion taking place primarily along plumbing runs. Over longer distances, bedbugs are recognised as being passively transported on furniture, bedding, and luggage.

### Significance of infestations

When bitten, some people will quickly show a substantial, red, itchy reaction (Figure 2), while others show no reaction at all. This absence of a response in many people, is one factor that hinders early detection of infestations. Although bites may sometimes become secondarily infected, research has consistently indicated that bedbugs do not transmit blood-borne infections, such as HIV or hepatitis.

As well as the health implications of bedbug infestation, the personal and financial impact can also be very considerable. It is not unusual for householders to throw away their mattresses, beds, bedding, carpets and other fittings in a desperate and costly effort to eradicate the infestation (Klein, 2001). For hotels, replacement of infested fittings, lost income on rooms that have been closed for treatment, and pest control fees, can amount to many tens of thousand of pounds. Hotel chains are also very concerned about the potential financial and public image costs of litigation from guests that have been bitten.

### Long-term trends

Before World War II bedbugs were abundant, with the UK situation reported as "in many areas all the houses are to a greater or lesser degree infested with bedbugs" (Ministry of Health Reports, 1933). However with the advent of synthetic insecticides, coupled with greater pest awareness, bedbugs were greatly reduced in many countries in the post-war years.

In less developed countries and regions, however, bedbug infestations have remained at a high level, with research in Tanzania indicating that 56% of homes were infested (Temu, 1999), and in Hyderabad, India, 65% of homes were infested (King *et al.*, 1989). In more developed countries, bedbug control is typically carried out by a mix of private,

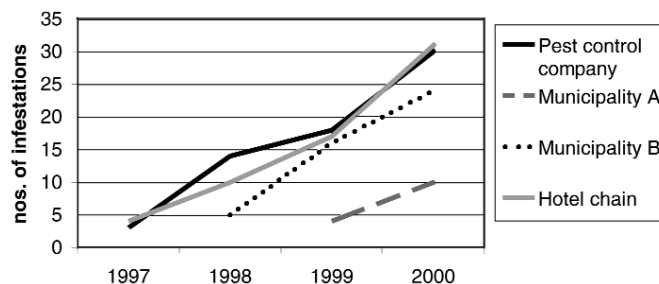


Figure 3. Numbers of bedbug infestations treated by selected UK pest control organisations.

municipal and in-house pest control organisations, but few keep records long enough to document long term trends. In addition, even where records exist, there is sufficient sensitivity associated with bedbug infestations for many organisation to be very reluctant to publicly release data on infestations. However the fragmented data available supports the much more widespread claim of an increase (Figure 3).

Elsewhere, there are also anecdotal reports from both Germany and Czech Republic of a very recent increase in bedbug infestations. One of the Arabian Gulf States has also documented a recent increase in numbers of bedbug infestations. In the USA, a recent article (Katz, 2000) reports that "pest management professionals throughout the United States have reported a nation-wide increase in calls for the control of bed bugs" and quotes Dr. Jerome Goddard of Mississippi State University as saying: "Bed bug problems seem to be coming back in a big way." As in Europe, US infestations are occurring in both hotels and private residences.

Although various hypotheses for this increase have been proposed, none has yet been substantiated. Increased travel and tourism is one factor that seems to be plausibly associated with the cycle of infestation between home and hotel, both nationally and internationally, and indeed the author has found luggage infested with bedbugs. However, of 39 separate infestations recently examined by the author in the London area, many of which were in locations with a high flux of international visitors, all were of the temperate *C. lectularius*, not *C. hemipterus*, the tropical bedbug. This tends to discount the tropical origin hypotheses, as being a significant factor in the increased numbers of infestations.

### No early warning

Insect monitoring devices play a very important role in pest control, in enabling infestations to be detected at an early stage, and in enabling the effectiveness of treatments to be judged. Unfortunately none is available specifically for bedbugs, and conventional crawling insect detectors are seldom effective at locating infestations. At present very little is known about behaviour modifying chemicals that may have a role to play in attracting and monitoring bedbugs. The literature reveals at least two alternative approaches to bedbug monitoring, that may just have some potential.

During the nineteenth century, bedbug traps were apparently widely used in the UK and in France. These consisted of flat, woven basket-work panels that were placed overnight behind the bolster in the bed, removed each morning, and the bugs shaken out and killed (Okey, 1930). One such trap is currently on display in the Cambridge Folk Museum, Cambridge. Presumably the bedbugs found harbourage in the basket-work, and bedbug faeces may have further increased its attractiveness. Another interesting approach involves trapping the bugs using the microscopic hooked hairs on the surface of leaves of certain plants, such as the bean *Phaseolus vulgaris*. In the Balkans, and in the former Southern Rhodesia, hooked leaves were left overnight on the floor of infested rooms, and were then swept up in the morning and burnt to destroy the bugs entangled on the leaves (Richardson, 1943).

### Physical control...

It has long been recognised that insects, including bedbugs, rapidly die if heated to about 50°C or higher. In recent years, several companies have developed sophisticated insect control systems based on heat treatment. These involve either encasing the entire building in an insulated envelope, or more typically placing items such as furniture, beds, mattresses, etc into a heated container. A microprocessor controlled heater ensures that target temperatures are maintained for the desired time. Such techniques are of interest to the hospitality industry, in that they leave no residues on treated items, are active against all life stages, against susceptible and resistant strains, and against insects concealed deep within items. However they do have limitations, in that typically the structure of the room remains to be treated with conventional insecticide, and heat-treated items are subsequently vulnerable to re-infestation.

Silica-based dust products, with a dessicant action on bedbugs, have also been very successfully used, although in many countries such products have recently been withdrawn by the manufacturer.

### ...and insecticidal control

However, most bedbug control is currently carried out using insecticides, and laboratory tests have shown that organophosphates, carbamates and pyrethroids are all active on susceptible strains (Fletcher and Axtell, 1993) (Table 2)

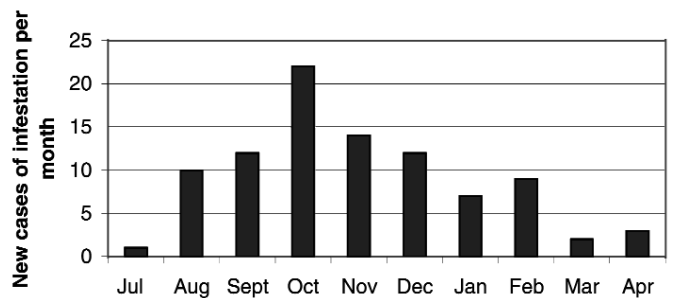
In practice, a range of 2nd generation pyrethroids including cypermethrin and deltamethrin, carbamates such as bendiocarb, or organophosphates such as pirimiphos-methyl, are widely used. However some organophosphates, despite their high intrinsic activity against bedbugs, are being withdrawn from public health use in some countries for regulatory reasons. For maximum effect, residual insecticide sprays should be very thoroughly applied as crack-and-crevice treatments, in order to contact the bugs whilst resting within their harbourages, as well as more general surface treatments. ULV insecticides and pyrotechnic devices are also used, although such treatments are likely to be less effective against insects deep in harbourages. Pre-

**Table 2. Intrinsic activity of residual insecticides on bedbugs\***

Dose-response of *C. lectularius* exposed for 24 h (at 25°C) to insecticide-treated filter paper. LC figures expressed as mg ai m<sup>-2</sup>

Insecticide	LC <sub>50</sub>	LC <sub>90</sub>
Dichlorvos	0.4	0.7
Pirimiphos-methyl	1.7	3.8
Lambdacyhalothrin	2.8	45.2
Bendiocarb	5.9	12.1
Permethrin	9.0	25.5

\*Data from Fletcher and Axtell, 1993.



**Figure 4. Progress of bedbug infestation in accommodation in Central London 1998-1999. The rapidly spreading bedbug infestation in this block was eventually brought under control by intensive treatment with a range of residual insecticides from November onwards.**

treatment preparation of a room may involve removing bedding, removing the fabric from the bottom of divan beds, loosening electrical fittings, taking down curtains, and emptying and inverting cupboards and drawers. Thoroughness is absolutely key to effective control of bedbugs (Figure 4). Pyrethroid treated mosquito nets have also proved active against bedbugs (Temu, 1999), and pyrethroid treated net products are now available as mattress covers.

Very limited data is available on the activity against bedbugs of more recent compounds, such as insect growth regulators. However recent tests carried out at the University of Wales, Cardiff, show a very substantial reduction in fecundity of female bedbugs exposed to the IGR pyriproxifen (personal communication) (Table 3). IGRs may have a significant role to play in the current outbreak, especially when used in mixture with conventional fast-acting insecticides to ensure both a rapid and a longer-term effect.

Although resistance in bedbugs to organochlorine insecticides was documented at an early stage, there has been no recent systematic work to identify any further changes. Nonetheless in Cambridge, UK, susceptibility tests have been carried out on insects taken from one field infestation of *C. lectularius*. Results indicate that, when compared to a fully susceptible laboratory colony, this field population had significantly decreased susceptibility at the LC<sub>50</sub> level to some pyrethroids and carbamates, but retained full suscepti-

**Table 3. Impact of insect growth regulator on bedbug fecundity.\* Treated glass plate placed in container with 13 female and 7 male bedbugs per replicate. Adults, nymphs and eggs monitored over 12 weeks.**

Treatment	Adult mortality	No. of eggs produced	% viable eggs	No. of nymphs emerging over 12 weeks
Pyriproxifen 1 mg ai m <sup>-2</sup> (as 10 EC)	No significant difference between treated and control	151	13.3	20
Untreated control		3629	96.5	3502

\*Data from University of Wales, 2000 (personal communication)

bility to the organophosphates insecticides tested (Medical Entomology Centre, Cambridge, personal communication). There is currently no information to indicate whether these results are indicative of the situation elsewhere, although there are numerous anecdotal reports of infestations that are particularly difficult to control.

### Beating biting bugs

On a broad level, this outbreak raises fundamental questions about pest outbreaks. We know very little about the underlying biological and mathematical mechanisms that within a few years, can push a previously uncommon urban pest into a widespread outbreak. Only by understanding those processes can we hope in the future to forecast outbreaks of urban pests and vectors, and to design evidence-based strategies that will effectively interrupt such outbreaks.

However in terms of turning this current bedbug outbreak around, three factors appear to be critical:

Firstly, there is an urgent need for a monitoring tool that would enable infestations to be identified rapidly, so that they can then be eliminated before they disperse and so extend the outbreak. At present it is probably true to say that any such developments are at least 2–3 years way.

Secondly, there is a similar urgent need for information on the current susceptibility status of bedbugs, to enable the most effective products to be identified. Concern among municipalities, the leisure industry and major pest control companies has now reached a point where a project to generate such data appears to be gelling.

Lastly, responsibility for record keeping on urban pests needs in some way to be consolidated, so that quantitative information is readily available to justify the need for appropriate action. However, with national and international responsibility for public health pests becoming fragmented between a range of private and public sector organisations, the chances of this happening appear to be increasingly remote.

For the immediate future then, the message must be check your bed regularly; you may have company.....

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