

BED BUG (HEMIPTERA: CIMICIDAE) RESURGENCE: PLOTTING THE TRAJECTORY

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Abstract The bed bug has had a longstanding relationship with low-income high-density housing. Proximity of dwellings, re-use of furniture, and control options limited by affordability, have all contributed to the continuation of this pest in such areas. The recent resurgence and spread of this pest may be attributed to the widespread appearance of resistance to commonly used insecticides, resulting in the development of extensive infestation reservoirs and networks in hotels, hostels, and urban apartments. The flux of people moving in and out of these traditional reservoirs has accelerated the resurgence, which now extends to public transport, leisure facilities, the workplace, and middle and high income hotels and accommodation. The resurgence has triggered the development of a wide range of novel bed bug detection and control technologies. Although these technologies are relatively expensive, elimination of bed bugs from upper-income hotels and housing will nonetheless be achieved, because these segments of society have the ability and motivation to pay for the measures. However there is a likelihood that the infestation network will remain largely intact in inexpensive hotels, hostels, and low-income housing, because the costs of these control methods are prohibitive for this sector. As a result, there is a risk that we will see the bed bug returning to economic exile, becoming a widespread and enduring household pest in the low socio-economic segment of society. The challenge is for the pest management industry, city authorities and agencies, housing managers and residents, to develop and implement bed bug control programs that are relevant and effective in this segment.

Key Words *Cimex lectularius*, reservoirs, infestation chain, low-income pest

INTRODUCTION

Bed bug infestations up until the mid 20th century were most common in houses, hotels, and hostels in the low income sectors of society (Marlatt, 1896; Ministry of Health, 1934; Busvine, 1951; Cornwell, 1974). Here the indoor conditions were suitable for proliferation and dispersion, and effective control measures limited. Infestations and bites were a regular feature of low-income and crowded conditions, whether urban or rural. This appears not to have been the case in upper-income households, but not because there was access to effective control materials. At this societal level there simply was little or no access to the pest. Society was more rigidly structured than now, and pests, people and possessions rarely crossed socio-economic lines. This resulted in the virtual containment of bed bug infestation in low income communities. The introduction of improved welfare provision for low income communities in the mid 20th century, together with the development of inexpensive and highly effective pesticides, drove *C. lectularius* yet further down the societal and income ladder. By the 1980s and 1990s, the bed bug was deep in economic exile.

The resurgence of the bed bug, *Cimex lectularius* L., has been on-going and largely unchecked for about 10 years. It has become a major pest in urban populations around the world (Boase, 2007; Doggett, 2008; Gangloff-Kaufmann et al., 2006; How and Lee, 2010; Kilpinen et al., 2008). This rapid move from relative obscurity to widespread abundance has been attributed to a number of factors. Probably the most important of these is that the bed bug has become resistant to most currently available insecticides, and the alternatives were either expensive, not readily available, or not particularly effective. It also appears likely that the much greater social and geographic mobility of the human population in the early 21st century, than in the early 20th century, has enabled the rapid resurgence and dispersion of these resistant insects. Globalisation and the economic downturn may have also played separate but contributory roles. Whatever the reasons, it seems that infestation sites and reservoirs became

established outside of the traditional low socio-economic sectors of society, and these fuelled the appearance of bed bugs in all levels of society.

At the current time, most infestations continue to be found in residential premises and hotels, at all socio-economic levels (Hwang et al, 2005). Importantly however, infestations are also reported in premises which are visited or used by a broad range of residents, including shops, theatres, offices and administrative buildings, together with transport such as railways, aircraft and ships. Infestations in these public or shared facilities, although relatively low in number, are likely to be important in terms of the transmission of infestation between different societal sectors. An infestation in a cinema or on public transport for example, comes into frequent contact with people from a broad range of socio-economic backgrounds.

RESEVOIRS AND INFESTATION CHAINS

Speculation now on the fate of the resurgence may seem premature, as the pest control industry, product manufacturers, hospitality and housing organisations, and residents, are still struggling to deal with the pest. However now may actually be the ideal time to step aside, look ahead, establish the trajectory of the resurgence, and try to identify appropriate goals for research and development. Examination of the bed bug as a pest, shows that it shares one key aspect of its ecology with some other formerly important household pests; there are no natural populations or natural reservoirs of this insect in the urban environment. This widespread and successful pest depends entirely on humans for food and habitat-to-habitat dispersal. This level of dependency leaves the bed bug vulnerable. In the recent past, a similar vulnerability has proved the undoing of the German cockroach, *Blattella germanica* (L.), and Old house borer, *Hylotrupes bajulus* (L.) (Robinson, 1999, 2002) and will likely do the same for the bed bug.

German Cockroach

The toppling of the German cockroach from top household pest status is often credited to the introduction and use of insecticide baits. The bait delivery system was important because it was effective, affordable, and applicable to the entire range of sites in which cockroaches were found. Use of baits resulted in high infestation reductions, and populations were quickly pushed to the tipping point and didn't 'recover', as they often did with liquid applications. This explains the successful control of individual infestations. However, the decline of *B. germanica* in the urban environment was based on the ability of baits to break the infestation chain that connected residential premises to food store to delivery truck to warehouse to manufacturer. Once elimination was achieved at the various links in the chain, there was little or no re-infestation (Boase, 2002). There were no natural reservoirs of *B. germanica* that could supply adults or nymphs for re-infestation. Without re-infestation, effective control became long-term elimination (Robinson, 1999).

Old House Borer

The decline of the old house borer as a structural-wood pest in the U.S. and other countries, can be attributed to the widespread use of pyrethroids, and the closing of small, local lumber mills. The profile of pyrethroid insecticides was ideal for treating old house borer infested wood. Good penetration, high toxicity, long residual activity (Powell and Robinson, 1992) and low odour resulted in their widespread use and the successful control of individual infestations. However the decline in the Old house borer as a structural pest was also brought about by the concurrent elimination of small lumber mills (and their replacement with large, well-organized mills). It was the small mills that acted as the infestation reservoir for this beetle, and supplied infested lumber that went to build houses, which would then produce adult beetles that dispersed and infested other houses. As small lumber mills closed, and infestations in homes were eliminated with pyrethroids, the chain of infestation was broken, and infestation levels then declined overall.

Bed Bug

The bed bug, *C. lectularius*, has characteristics and habitat dependency similar to those of the German cockroach and Old house borer. Like those two pests, there appears to be no reservoirs outside of the urban environment, but only a chain of infested premises that includes households, hotels and hostels, and low-income transient housing. Dispersal along the chain is primarily through personal belongings, such as luggage, re-used furniture, and over short distances by active movement from apartment to apartment. It is likely that rapid detection and effective treatment of infestations at key links in the chain, i.e. those with a high potential for transfer of bed bugs between individuals, and between societal levels, will break the chain of transmission, and so bring the resurgence to a halt.

THE END GAME

The battle for control of the bed bug is now fully engaged, and techniques include a range of educational tools, detectors and traps, barriers, extreme temperatures, fumigants, and insecticides, coupled with a more integrated approach to bed bug management. This level of technology and technician time is effective, even against resistant bed bugs, but it is expensive and is likely to remain that way.

Nonetheless the economic, aesthetic and litigation pressure on hotels, provides the motivation to invest in these measures. Similarly, middle to high-income households can afford to avoid suspect hotels, and afford the cost of elimination in the event that they do acquire infestation. For these sectors, investment in eradication is worthwhile, because the risk of re-infestation will decline. Once most hotels have comprehensive prevention and control measures in place, infestation levels will drop dramatically, as will infestations in their guests' homes. Once enough of the links in the re-infestation network have been broken, the rate of appearance of new infestations will fall rapidly, the resurgence in middle and upper socio-economic levels will then flatten out, and tip over into decline.

By contrast, the low-income sector of society is unlikely to be able to afford these technology-intensive treatment methods. For the time being they will have to rely on lower-cost techniques, which are in general less effective. In any case, the incentive to pay for eradication is lacking, since re-infestations levels are likely to remain relatively high, making investment in local eradication temporary in effect, and therefore wasteful of limited financial resources. Low-income housing residents and managers will become saddled with a pest problem they cannot afford to fix. This situation has many parallels to the position with German cockroaches in the 1980's, before modern insecticide baits were introduced.

Although the gradual disappearance of bedbugs from middle and high socio-economic sectors, will result in a decrease in the media coverage, this 'economic exile' of the pest will remain a long-term concern for all levels of society. Owing to the less segregated nature of 21st century society, as compared with the early 20th century, there will remain greater opportunities for movement of infestation between societal levels. The challenge therefore is to develop sustainable and effective bed bug management programs that are relevant to low income communities, and their bed bug reservoirs. The key participants in this final phase of the trajectory include pest control product manufacturers, pest control operators, the research community, environmental health and social service agencies, city authorities, housing managers, and of course the residents themselves. Only through the co-ordinated, focussed and creative efforts of these stakeholders, will the bed bug end-game finally be played out.

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