

*ADVANCES IN THE BIOLOGY AND MANAGEMENT OF MODERN BED BUGS – A
NEW TEXT*

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Abstract The modern bed bug resurgence has been as unexpected as it has been dramatic, with no sector of society being exempt from a possible infestation. Perhaps one of the most unusual aspects of the resurgence is that it has simultaneously involved two species, the Common bed bug, *Cimex lectularius* L., and the Tropical bed bug, *Cimex hemipterus* (F.). The return of these public health pests has prompted a renewed interest in bed bug research and numerous papers have been published in recent years covering a multiple of disciplines. It is now becoming difficult for the average researcher to assimilate all the information available on bed bugs and thus there is a need for a new academic text that reviews all the literature from the past to the present, and offers it in a readily digestible form. Hence the birth of the new text, *Advances in the Biology and Management of Modern Bed Bugs* (ABMMBB).

Key words *Cimex lectularius*, *Cimex hemipterus*, resurgence, new textbook.

INTRODUCTION

It has been just over 50 years since the publication of Robert Usinger's seminal text, *Monograph of Cimicidae*. At the time of publication in 1966, bed bugs were on the global decline, apparently defeated forever through the use of the powerful insecticides, including DDT (and other organochlorines) and organophosphates. Then in the late 1990's reports of bed bugs becoming more common started to surface in academic publications.

A letter appeared in the *Medical Post*, suggesting anecdotally that bed bugs were becoming increasingly common in the UK and that only the older pesticides were effective (Birchard, 1998). This paper was also the first to hint at a possible key trigger of the modern resurgence, namely the development of insecticide resistance within bed bugs. Another letter sent to the *British Medical Journal* in 2000, also suggested a possible resurgence, the authors stating that they had received four bed bug samples in 1999, compared to one in 1998 (Paul and Bates, 2000). However, the first paper that provided concrete data of a bed bug resurgence was from Australia in 2004, where the authors had recorded an increase of over 400% in the number of bed bug samples submitted to their pathology service since the beginning of 2001. In addition, some pest management companies had seen a rise in treatments of almost 700% during a similar period (Doggett et al., 2004). The same group had previously reported on the presence of the Tropical bed bug, *Cimex hemipterus* (F.), for the first time in Australia (Doggett et al., 2003), pointing to a resurgence of both *C. hemipterus* as well as the Common bed bug, *Cimex lectularius* L. In the US, pest management industry publications also reported an anecdotal increase

in the number of bed bug treatments from the late 1990's and early 2000's (Pinto, 1999; Katz, 2000, Anon, 2001; Anon, 2002). Subsequently, reports of bed bug resurgence began to appear from all around the world.

With the global rise of bed bug populations, there has also been a renewed interest in bed bug research. Over the years 2000-2016, the citation indexing service, PubMed, listed 459 peer-reviewed papers on *Cimex*, but only 259 between the years 1912-1999 (Figure 1). Furthermore, research has occurred across disparate fields making it challenging for all scholars and anyone dealing with bed bug management to keep up-to-date with contemporary investigations and innovations. Thus there is a need to distil all of this research into a modern text, and hence the birth of *Advances in the Biology and Management of Modern Bed Bugs (ABMMBB)*.

ABMMBB – AN OVERVIEW

ABMMBB is a complete synthesis of bed bug information from the past to the present and has more than some 60 contributors, including many of the most recognisable names in the field of bed bugs today. There are seven main sections, 45 chapters, a forward (kindly provided by Dr Harold Harlan), an introduction by the editors, and a conclusion that examines the future of bed bugs and research priorities (Table 1).

The first section, *Bed Bugs in Society*, contains two papers. The initial chapter, *Bed Bugs Through History*, reviews the early methods of extermination, and the origins and subsequent spread of bed bugs throughout the world. The second chapter, *Bed Bugs in*

Popular Culture, demonstrates the intimate relationships between humans and bed bugs through history, and how the insect has have appeared in various forms of popular culture. For example , bed bugs have appeared over the years in poetry, art, the theatre, literature, music, and more recently, in television. Bed bugs were a popular topic of postcards during the early 1990's (Figure 2) and have even been used in erotica.

The section on *The Global Bed Bug Resurgence* contains contributions from all the major regions across the world, including chapters from North America, South America, Europe and Russia, Asia, Africa, the Middle East, India and the subcontinent, and Australia. Each chapter reviews the history of bed bugs in their respective region, and discusses the resurgence and strategies employed to combat the return of the bed bug.

Bed Bug Impacts reviews the dermatological, mental health, and miscellaneous health impacts associated with bed bugs. The evidence and potential for bed bugs to transmit infectious diseases is also discussed. While the health related impacts of bed bugs are arguably relatively minor (especially compared with known vectors), the fiscal impacts are highly significant. Thus the last chapter of this section reviews the monetary impacts caused by bed bugs.

Bed Bug Biology covers topics such as host seeking and blood feeding behaviours, harbourage selection and aggregation, dispersal, chemical ecology, population genetics, physiology, symbionts, and laboratory maintenance. Including aspects of biology in ABMMBB is important as such information forms the basis of control programs.

The section, *Bed Bug Management*, begins with a review of the three main industry standards that have been developed to help guide bed bug management practices. These are followed by a chapter on how a large multinational pest management firm deals with bed bug management to ensure a consistency of treatments and a positive outcome, by all of their technicians. Also included are chapters on prevention (which is largely about reducing the risk of bed bugs), detection and monitoring, non-chemical management, insecticide resistance, and chemical control. With the emergence on the market of many products that are not very efficacious, the next chapter, focuses on the inherent limitations in bed bug management technology. The final chapter centres on bed bug education and ensuring that correct message is given to the community on how to minimize the risk of bed bugs and how to properly manage an infestation.

In *Bed Bug Control in Specific Situations*, experts in the industry highlight the challenges they have experienced in managing bed bugs in some of the most difficult situations possible. Discussed are the various issues faced in achieving control and the key elements that have led to a successful outcome.

With the growing litigation over bed bugs, the theme of the last section is *Bed Bugs and the Law*. Topics include the legal requirements of professional pest managers and the products they use, laws relating to bed bugs, and legal cases studies involving bed bugs.

ABMMBB – OBJECTIVES & RELEASE DATE

ABMMBB aims to be a reference book for academic researchers and students alike, however it is written in an easy to read format, making the information accessible to all. It will prove to be a valuable text for those in the hospitality industry and accommodation managers, who are tasked with the job of minimizing the risk of bed bugs in their facility, or have to manage the processes of eradication of active infestations. With the growth in bed bug litigation across the world, both the litigant and defendant legal teams will find *ABMMBB* an indispensable source of contemporary information, which will assist in their legal preparations. Importantly, *ABMMBB* provides up-to-date information for the professional pest manager on bed bug biology and management. *ABMMBB* is to be published by Wiley-Blackwell and due for release in late 2017.

References

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Katz, H. 2000. Bed bugs make a comeback. *Pest Cont. Technol.* 28: 79-81.

Paul, J. and Bates, J. 2000. Is infestation with the common bedbug increasing? *BMJ* 320: 1141.

Pinto, L. 1999. Bed bugs...they're back. *Pest Cont.* 67: 10.

Table 1. Contents and Authors of *Advances in the Biology and Management of Modern Bed Bugs*.

Chapter Title	Author/s (Country)
Forward	Harold Harlan (US)
Introduction by the editors	Stephen Doggett (Australia), Dini Miller (USA), Chow-Yang Lee (Malaysia)
<i>Section 1 – Bed Bugs in Society</i>	
Bed Bugs Through History	Michael Potter (USA)
Bed Bugs in Popular Culture	Stephen Doggett (Australia), David Cain (UK)
<i>Section 2 – The Global Bed Bug Resurgence</i>	
North America	Dini Miller (USA)
South America	Robert Pereira (USA), Ana de Carvalho Campos and Marcio Lage (Brasil)
Europe and Russia	Richard Naylor (UK), Ondřej Balvín (Czech Republic), Pascal Delaunay and Mohammad Akhoundi (France)
Asia	Chow-Yang Lee (Malaysia), Motokazu Hirao (Japan), Changlu Wang (USA), and Yijuan Xu (China)
Australia	Stephen Doggett and Toni Cains (Australia)
Africa	Josephus Fourie and Dionne Crafford (South Africa)
India and the Subcontinent	Anil Rao and Joshua Rao (India)
The Middle East	Odelon Del Mundo Reyes (United Arab Emirates)
<i>Section 3 – Bed Bug Impacts</i>	
Dermatological and Immunology	Shelley Ji Eun Hwang, Stephen L. Doggett and Pablo Fernandez-Penas (Australia)
Infectious Diseases	Stephen Doggett (Australia)
Mental Health	Stéphane Perron, Geneviève Hamelin and David Kaiser (Canada)
Miscellaneous Health Impacts	Stephen Doggett (Australia)
Fiscal	Dini Miller and Karen Vail (USA), Stephen Doggett (Australia)
<i>Section 4 – Bed Bug Biology</i>	
Biology - Overview	Sophie Evison, William T. Hentley, Rebecca Wilson and Michael T. Siva-Jothy (UK)
Chemical Ecology	Gerhard Gries (Canada)
Population Genetics	Warren Booth, Coby Schal and Edward Vargo (USA)
Bed Bug Physiology	Joshua Benoit (USA)
Bed Bug Symbionts	Mark Goodman (USA)
Laboratory Maintenance	Mark Feldlaufer (USA)
<i>Section 5 – Bed Bug Management</i>	
Management Standards; Australia	Stephen Doggett (Australia)
Management Standards; Europe	Richard Naylor (UK)

Management Standards; USA	Jim Fredericks (USA)
A Pest Control Company Perspective	Joelle Olson (USA), Mark Williams (UK), and David Lilly (Australia)
Prevention	Molly Steadfast and Dini Miller (USA)
Detection and Monitoring	Richard Cooper and Changlu Wang (USA)
Non-Chemical Control	Stephen Kells (USA)
Insecticide Resistance	Alvaro Romero (USA)
Chemical Control	Chow-Yang Lee (Malaysia), Dini Miller (USA) and Stephen Doggett (Australia)
Limitations in Bed Bug Management Technologies	Stephen Doggett (Australia) and Mark Feldlaufer (USA)
Education	Jody Gangloff-Kaufmann and Allison Taisey-Allen (USA)
<i>Section 6 – Bed Bug Control in Specific Situations</i>	
Low Income Housing	Richard Cooper and Changlu Wang (USA)
Multi-unit Housing	Dini Miller (USA)
Shelters	Molly Steadfast (USA)
Hotels	David Cain (UK)
Health Care Facilities	Stephen Doggett (Australia)
Aircraft	Adam Juson and Catherine Juson (UK)
Cruise Ships and Trains	David Lilly and Garry Jones (Australia)
The Poultry Industry	Alan Szalanski (USA)
<i>Section 7 – Bed Bug Legal Issue</i>	
USA	Jeffery Lipman and Kolby Warren (USA)
United Kingdom	Clive Boase (UK)
Australia	Toni Cains, David Lilly and Stephen Doggett (Australia)
Asia	Andrew Ho (Singapore)
Being an Expert Witness	Paul Bello (USA)
<i>The Future</i>	
The future including research imperatives	Chow-Yang Lee (Malaysia), Dini Miller (USA) and Stephen Doggett (Australia)

Figure Legends.

Figure 1. The number of citations per year, 1912 to 2016, under Pubmed using the search term 'Cimex'.

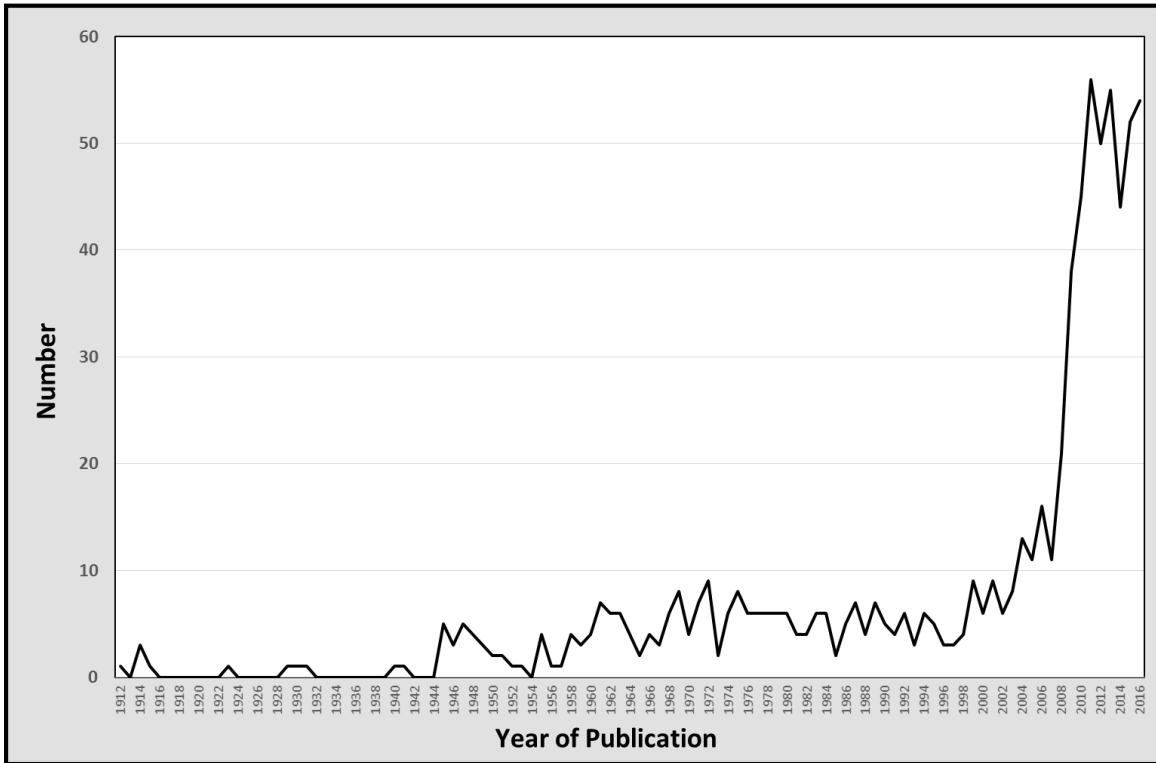


Figure 2. An example of postcards depicting bed bugs from the early 1900's. From the private collection of David Cain and Stephen Doggett.

