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RESURGENCE OF BED BUGS (HEMIPTERA: CIMICIDAE) IN MAINLAND CHINA

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Abstract

Bed bugs were common pests worldwide before World War II. They were almost completely eradicated in many countries by good hygienic conditions and application of insecticides. These pests are currently reemerging in many developed countries. We conducted a literature review and an internet search using the key word, bed bugs, to evaluate the status of bed bug resurgence in China. The results showed that the occurrence of bed bugs dramatically increased from 4 reports in 2007 to 67 in 2012. Bed bug infestations were reported from 23 provinces of China, with the most severe infestations occurring in Guangdong Province. Bed bugs were reported to commonly invade dormitories, private homes, rented houses, and public transportation facilities. Based on internet reports, about half of the people bitten by bed bugs claimed to have developed clinical reactions, and approximately 5% required medical treatment. This study demonstrates that China also has undergone a bed bug resurgence, which should be addressed by the multidisciplinary actions involving both governments and the public.

Key Words: *Cimex* spp., insecticide resistance, clinical reactions

Resumen

Los chinches de cama eran una plaga común por todo el mundo antes de la Segunda Guerra Mundial. Tras ésta, la plaga fue prácticamente erradicada en muchos países debido a unas condiciones higiénicas adecuadas y a la aplicación de insecticidas. En la actualidad, estos insectos están resurgiendo en muchos países desarrollados. Para conocer la situación en China de esta plaga se ha realizado una revisión bibliográfica y una búsqueda en Internet utilizando como palabra clave, "bed bugs". Los resultados obtenidos mostraron que la presencia de chinches ha aumentado drásticamente, de 4 informes encontrados en el año 2007 a 67 en el 2012. Estas infestaciones de chinches de cama se registraron en 23 provincias de China, dándose la infestación más grave en la provincia de Guangdong. Los chinches de cama fueron mayoritariamente encontrados en dormitorios, casas particulares, casas de alquiler y en servicios de transporte público. Según los informes encontrados en Internet, alrededor de la mitad de las personas picadas por estos insectos afirmaron haber desarrollado reacciones clínicas y aproximadamente el 5% requirió de tratamiento médico. Este estudio demuestra que China también ha experimentado un resurgimiento de chinches de cama, que debería ser abordado mediante acciones multidisciplinares que involucren tanto a los gobiernos como al público.

Palabras Clave: Cimex spp, resistencia a insecticidas, reacciones clínicas

Bed bugs (Hemiptera: Cimicidae) are small blood-sucking insects (Thomas et al. 2004). Two species, namely, the common bed bug *Cimex lectularius* L. and the tropical bed bug *Cimex hemipterus* (Fabricius), feed upon human blood (Delaunay et al. 2011). All nymphal stages and both genders of adults need to feed on blood to grow and reproduce (Reinhardt & Siva-Jothy 2007). Many people are sensitive to their bites (Reinhardt & Siva-Jothy 2007) such that a skin reaction often occurs after one is bitten and red itchy welts emerge. Secondary bacterial infections may occur because of scratching (Kolb et al. 2009), although bacterial infections are rare in otherwise healthy individuals (Doggett et al. 2012). Although transmission of disease agent from bed bugs to humans has not been reported to date (Doggett et al. 2012), bed bug infestations may impact the mental health of individuals. People can experience discomfort, anxiety, lack of sleep, and ostracism because of bed bug bites (Davies et al. 2012; Thomas et al. 2004; Romero et al. 2007). Bed bugs can cause severe anemia (Paulke-Korinek et al. 2012; Pritchard & Hwang 2009; Venkatachakam & Bekvadt 1962), also their allergens may induce asthmatic reactions (Doggett et al. 2012).

Bed bugs afflicted people for millennia before 1940s (Kolb et al. 2009). Reductions in the incidence of these parasites in developed countries after World War II were believed to be the re-

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sult of improvements in sanitation and the use of pesticides (Doggett et al. 2004; Delaunay et al. 2011). Nevertheless, in the past decade bed bugs have resurged in many parts of the world, including Southeast Asia, Japan, Europe, North America, Australia, and Africa (Davies et al. 2012). Therefore the medical community's interest in bed bugs has increased dramatically over the past 10 yr (Delaunay et al. 2011). In Australia and the United States, hotels, apartments, private homes, and rented properties are at risk of bed bug infestation (Doggett & Russell 2008; Potter et al. 2010). The recent reemergence of these pests is likely to be caused by: (1) major increases in international travel including travel by middle income people, (2) high levels of insecticide resistance among bed bugs, and (3) poor or non-existent pest management practices (Williams & Willis 2012; Doggett et al. 2012). Szalanski et al. (2008) indicated that high levels of gene flow in bed bug populations result in the rapid spread of insecticide resistance.

Bed bugs have largely been ignored in mainland China because of the success of the Patriotic Public Health Campaign undertaken under Chinese Government. Bed bug populations in China were dramatically reduced by the Government-led campaigns conducted from 1960 to the early 1980s (Wang & Wen 2011). However, in recent years, bed bug control has become the primary business of pest control companies in some cities in South China (Shen 2011). The increasing prevalence of bed bug populations in recent decades highlights the importance of understanding the potential harm to public health caused by *C. lectularius* and *C. hemipterus* and more importantly the economic impact on China, which appears to be far more significant than human health impact. To this end we performed an internet search and reviewed the literature to explore the status of bed bug resurgence in mainland China. We also analyzed the clinical reactions associated with bites in humans based on research reports published on the China National Knowledge Infrastructure (CNKI) website, http://www.cnki.net.

Methods

Internet Search and Literature Review

We obtained relevant data on the distribution of bed bugs and other information related to their attacks on humans using the Chinese language search platform Baidu (www.baidu.com) and the CNKI website http://www.cnki.net/. We searched for reports about bed bugs between 2000 and Oct 2012 using "bed bugs" in Chinese as the key word and obtained 21 news reports and journal articles about biting events (Dong et al. 2000; Zhou et al. 2000; Chen et al. 2001; Wen et al. 2001; Chen et al. 2002; Hao 2002; Diwu et al. 2003; Jiang et al. 2003; Xu et al. 2003; Wang et al. 2006; Cao et al. 2007; Li et al. 2007; Fang 2008; Sun et al. 2008; Zhou et al. 2009; Qin et al. 2010; Zhang et al. 2010; Li et al. 2011; Bo et al. 2012; Chen et al. 2012; Yu et al. 2012). Based on the data from these reports, we analyzed the distribution and resurgence of bed bugs in mainland China.

Statistical Analysis

All statistical data were tested for normal distribution using the Shapiro-Wilk test and for homogeneity of variances using Levene's test with SPSS 18.0. χ^2 analysis was used to compare the major places that had been infested by bed bugs. Differences in percentages of clinical reactions and non-reaction of people bitten by bed bugs were evaluated using the *t* test.

Results

The number of reports in China documenting bed bug plagues of *C. lectularius* was 24 (21 literature reports from CNKI and 3 internet-based news reports), which was higher than the number for *C. hemipterus* ($\chi^2 = 16.333$, $P < 0.0001$) (Fig. 1). However, bed bug outbreaks were distributed in 23 provinces across China, and Guangdong Province, located in the tropics of South China, had the highest proportion of bed bug reports (Fig. 2). These data warrant further investigation of specific occurrences of the different bed bug species.

Based on internet research, we found that public concern about the reemergence of bed bugs has increased dramatically since 2007. More than 70% of the 21 literature reports in China on bed bug plagues occurred during 2010-2012. Only 4 outbreaks were reported in 2007; by contrast, 64 outbreaks were reported in only the first half of 2012. These findings suggested that bud bugs had recently become more common in mainland

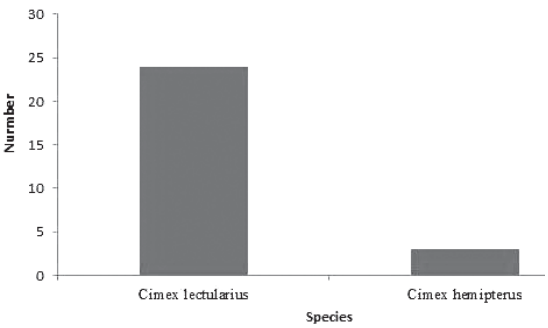


Fig. 1. Recorded numbers of reports of *Cimex lectularius* and *C. hemipterus* in China ($\chi^2 = 16.333$, $P = 0.000$). The data were derived from reports found by searching Baidu and the CNKI website (http://www.cnki.net/).

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Fig. 2. Frequency of reports of bed bugs in various provinces of mainland China. Abbreviations: AH, Anhui; BJ, Beijing; FJ, Fujian; GS, Gansu; GD, Guangdong; GX, Guangxi; GZ, Guizhou; HN, Hainan; HLJ, Heilongjiang; HB, Hebei; HN, Henan; HB, Hubei; JL, Jilin; JS, Jiangsu; LN, Liaoning; SC, Sichuan; SD, Shandong; SH, Shanghai; SN, Shanxi, SX, Shanxi; XJ, Xinjiang; YN, Yunnan; ZJ, Zhejiang. Data on the distribution of bed bugs were collected by searching Baidu and the CNKI Web site (http://www.cnki.net/) for reports covering the period of 2000-2012.

China (Fig. 3). Dormitories, private homes, and rented houses have become the most frequently infested sites ($\chi^2 = 102.436$, $P < 0.0001$; Fig. 4).

We obtained 21 journal articles about events related to bed bugs biting humans by searching the CNKI website (http://www.cnki.ent/) and then we screened out 8 (Wen et al. 2001; Chen et al. 2001; Diwu et al. 2003; Zhang & Diwu 2003; Li et al. 2007; Cao et al. 2007; Su et al. 2008; Zhou et al. 2009) that gave accounts of physical reactions to the bites. The data showed that more than 50% of people bitten had clinical reactions, a rate not significantly different from that documented for people who did not exhibit any reaction (t = -0.653, P = 0.524; Fig. 5). The literature review showed that 56.71%, 9.62%, and 2.84% of affected individuals experienced pruritus and dermatitis, sleeplessness, and dizziness, respectively. Furthermore, 5.1% of people who were bitten by bedbugs requested treatment (Fig. 5).

Discussion

Cimex spp. is a minor threat to human health because they do not transmit agents of human disease. Our study indicates that the incidence of bed bug outbreaks have increased and especially in recent years. Temperature and latitude are key factors determining the geographical distribution of the 2 *Cimex* spp. (Deng & Meng 1952; Zhou et al. 2000). Doggett et al. (2011) indicated that *C. hemipterus* were widespread in the subtropical and tropical regions north of the 29 °S in Australia. Newberry & McHunu (1989) reported that both

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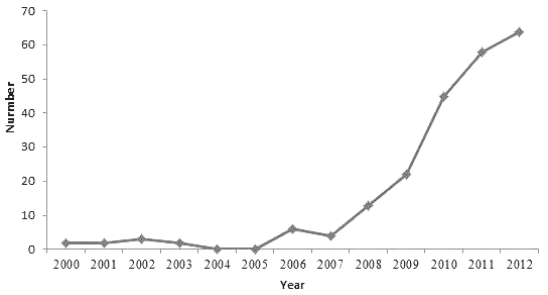


Fig. 3. Incidents of harm to humans caused by bed bugs as reported in all internet reports for the period of 2000-2012. The data were derived from reports found by searching Baidu and the CNKI website (http://www.cnki.net/).

C. hemipterus and *C. lectularius* were common in the Nkundusi-Mfekayi area of South Africa (S 28° 15'). These results are similar to those of Deng & Meng (1952) in China. The survey of Deng & Meng (1952) indicated that *C. lectularius* was widely distributed in regions from Heilongjiang province (N 48° 16') to Yunnan province (N 23° 23'), and the natural northern boundary of *C. hemipterus* distribution in China is Sichuan province (N 30° 41'). Zhou et al. (2000) reported that the tropical bed bug was distributed only south of the Tropic of Cancer, and that the common bed bug occurred mainly north of the Tropic of Cancer in Guangxi province. Also *C. hemipterus* was recently found in Fujian province (N 26° 07') (Li et al. 2011). The results showed that N 30° latitude may be the natural northern boundary of *C. hemipterus* in China.

Our study shows that bed bugs annoyed people in 23 of 34 provinces and regions in China during 2000-2012. Previous research also indicated that bed bug issues had been registered in 40% of the counties in Shaanxi and 90% of the counties in Guangxi (Zhou et al. 2000; Diwu et al. 2003). Furthermore, bed bugs have been found in some vehicles, such as passenger trains and ships (Dong et al. 2000; Qin et al. 2010; Li et al. 2011; Chen et al. 2012; Zhang et al. 2010; Bo et al. 2012). These indicate that bed bugs have been spread from infested to uninfested regions through public transportation. Dormitories, private homes, and rented houses have been found to be the most infested places in mainland China, as was also reported for Australia (Doggett 2007) and the USA (Potter 2010). The results demonstrate that bed bugs had not been not completely eradicated in China, but had merely become very uncommon, as in many developed nations around the world. If not controlled well, these pests have the potential cause severe plagues throughout the country.

We found that the occurrence of bed bugs reports is more frequent in Pearl River Delta region than in interior areas. Wang and Wen (2011) also revealed the same phenomenon through telephone interviews of Health and Epidemics Prevention Stations and pest control companies. Moreover, the probability of detecting bed bugs in workers' dormitories is very high. This phenomenon can be attributed to the following 3 reasons. (1) Increased population migration in the Pearl River Delta region, which is economically well-developed and thus has much domestic and international communication. Bed bugs may have spread to Pearl River Delta region through human migration and



Fig. 4. Types of properties where bed bugs have been commonly detected in China ($\chi^2 = 102.436$, $P = 0.000$). The data were derived from reports found by searching Baidu and the CNKI website (http://www.cnki.net/).

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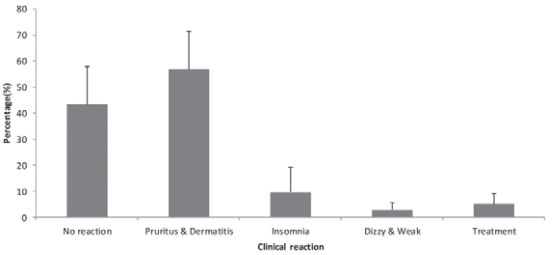


Fig. 5. Clinical reactions of people to bed bug bites in mainland China (sample numbers: $n1$ = 143 (Wen et al. 2001); $n2$ = 30 (Chen et al. 2001); $n3$ = 1246 (Diwu et al. 2003); $n4$ = 1780 (Zhang & Diwu) 2003; $n5$ = 96 (Li et al. 2007); $n6$ = 297 (Cao et al. 2007); $n7$ = 60 (Su et al. 2008) and $n8$ = 148 (Zhou et al. 2009).

product transportation. (2) Poor housing conditions associated with the frequent migration of workers, which provides favorable conditions for the survival and reproduction of bed bugs. In addition, widespread ignorance of bed bug biology, ecology and control favors their survival and buildup. Apartment tenants may conceal bedbug infestations from dormitory managers for fear of financial penalties or eviction (Moore & Miller 2009); and, industrialists are often not willing to pay the additional costs of preventing and controlling bed bugs and other pests in worker dormitories. By contrast, inland regions have less communication with the outside world and less dynamic industrialization than Pearl River Delta region, and these factors impede the buildup of bed bug populations. However, the acceleration of urbanization in China is attended by accelerating large-scale population movement and transportation of materials, and these dynamic conditions favor the increased dissemination and buildup of bed bug populations. Therefore, the public must learn to recognize these pests and signs of their presence, and become familiar with the fundamentals of their biology and ecology in order to forestall or eliminate infestations. For example, the purchase or acceptance of unregulated sale, donation, importation, and smuggling of second-hand clothing and mattresses, which serve as hiding places of bed bugs (Potter et al. 2010), should be avoided and an efficient "search-and-destroy" operation must be imposed on anything possibly infected by bed bugs (Delaunay et al. 2011). The relevant government departments must focus more attention on groups and situations with a high risk for bed bug infestation and provide pest control companies and the public with science-based technology and training to cope with this scourge. Professional cooperation in the inspection, identification, and bed bug eradication programs will result in successful elimination of these pests. Tighter quarantine procedures for products and people from bed bug-infested regions should be implemented. Chinese entomologists must investigate the specific ecological conditions which currently facilitate build ups of bed bug populations and develop more practical and efficacious control options. A carefully developed and widely disseminated program bed bug biology, ecology, prevention and control could greatly limit the health and economic impacts of bed bugs in China.

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