

Survey of bed bugs in infested premises in Malaysia and Singapore

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ABSTRACT: A total of 54 bed bug-infested sites (hotels, public accommodations, and residential premises) in Malaysia and Singapore was surveyed between July, 2005 and December, 2008. Only one species of bed bug was found, the tropical bed bug *Cimex hemipterus* (Fabricius). Bed bug infestations were common in hotels and public accommodations when compared to residential premises. The three most common locations of infestation within an infested premise were the bedding (31.1%), the headboard (30.3%), and cracks and crevices surrounding the baseboard, wall, or floor (23.5%). We speculate that the route of movement of bed bugs in hotels and public accommodations is more direct than in residential premises. *Journal of Vector Ecology* 35 (1): 89-94. 2010.

Keyword Index: *Cimex hemipterus*, tropical bed bug, hotels, residential premises, Malaysia, Singapore.

INTRODUCTION

The resurgence of bed bug infestations has gained worldwide attention, especially among pest management professionals (Potter 2005, 2006). Increasing numbers of bed bug infestations were reported in the U.S.A. (Krueger 2000), Europe (Owen 2004), Canada (Hwang et al. 2005, Myles et al. 2003), Italy (Masetti and Bruschi 2007), Australia (Doggett et al. 2003, 2004), and Korea (Lee et al. 2008). Bed bug bites are a medical nuisance to humans; they may cause cutaneous reactions such as erythema, wheals, vesicle formation, and hemorrhage (Goddard and deShazo 2009, Kolb et al. 2009, Thomas et al. 2004). Repeated bites cause skin lesions and, in some cases, victims develop systemic hypersensitivity (Thomas et al. 2004) or even severe hemoglobin loss (Venkatachalam and Belavady 1962). Scratching wounds that develop after bites may even trigger secondary infections, including folliculitis, cellulitis, or eczematoid dermatitis (Allington and Allington 1954, Crissey 1981, Goddard and deShazo 2009). The cryptic behavior of bed bugs may also prompt delusory parasitosis among homeowners and hoteliers (Hinkle 2000). Bed bug infestation also has been one of the major factors contributing to economic losses in the hospitality and tourism industry (Doggett 2006).

In Southeast Asia over the past five years, pest management professionals have reported bed bug management to be increasingly important. Most of these reports have been anecdotal in nature and were published in local newspapers and other trade magazines. No information about bed bug infestation in this region is available in the scientific literature. Thus, we initiated a survey in Malaysia and Singapore that was conducted with the help of pest management professionals to determine (1) the bed bug species present, (2) the frequency of infestation, and (3) the distribution of bed bugs within different types of premises. The information generated will assist pest

management professionals in designing an effective bed bug management program.

MATERIALS AND METHODS

Surveys of 54 infested premises in Malaysia [Kuala Lumpur (03°08'N, 101°42'E) and Penang (05°30'N, 100°28'E)] and Singapore (01°18'N, 103°50'E) were conducted between July, 2005 and December, 2008 (Table 1). Inspections were made with flashlight and fine forceps (Harlan 2006). Infested locations within the inspected premises were categorized as: (1) bedding (including pillow, bed sheet, mattress, and bed frame); (2) headboard; (3) walls and floor (including the baseboard and cracks and crevices in these locations); (4) sofa cushions; (5) rattan chairs; (6) wooden furniture; and (7) other non-wooden furniture or appliances. Bed bug infestations also were identified by the presence of blood fecal spots, shed exoskeletons, empty egg cases, live or dead adult bed bugs, nymphs, and eggs (Doggett 2006, King et al. 1989, Mallis 1990, Usinger 1966). The collected bed bugs were brought back to the laboratory and identified under a stereo microscope (Olympus SZ61, Olympus Corporation, Tokyo, Japan) according to keys published by Usinger (1966). All analyses were performed using Statistix Version 7.0 (Analytical Software, Tallahassee, FL, U.S.A.).

RESULTS AND DISCUSSION

Only one species of bed bug, the tropical bed bug *Cimex hemipterus* (Fabricius), was found in all 54 sites inspected (Table 1). Unlike *Cimex lectularius* (L.) which is most prevalent in the temperate region (Boase 2004, Hwang et al. 2005, King et al. 1989, Paul and Bates 2000), *C. hemipterus* is the most dominant species in tropical and subtropical regions (Mallis 1990, Usinger 1966). In Australia, Doggett et al. (2003, 2004) reported that *C. hemipterus* prefers a

Table 1. Bed bug collection sites in Malaysia and Singapore, species found, and the severity of infestations (n = 54 sites).

Country	City	Collection Date & ¹ Code	Premises	Infestation Status	² Infestation severity rank	<i>Cimex</i> Species
Malaysia	Penang	21 Jul 2005; M-KM A5	Residential house & flat	Active	3	<i>C. hemipterus</i>
		27 Jul 2005; M-KM A14	Residential house & flat	Active	3	<i>C. hemipterus</i>
		28 Jul 2005; M-DK	Residential house & flat	Active	5	<i>C. hemipterus</i>
		11 Dec 2005; M-LP	Residential house & flat	Inactive	0	-
		19 Dec 2006; M-PA	Hotel	Active	N.A.	<i>C. hemipterus</i>
		11 Oct 2008; M-GE	Residential house & flat	Active	3	<i>C. hemipterus</i>
		22 Oct 2008; M-PFS	Residential house & flat	Active	3	<i>C. hemipterus</i>
	Kuala Lumpur	23 Nov 2005; M-LY	Residential house & flat	Active	1	<i>C. hemipterus</i>
		18 Jan 2006; M-PR	Hotel	Active	1	<i>C. hemipterus</i>
		7 Aug 2006; M-G1	Hotel	Active	1	<i>C. hemipterus</i>
		7 Aug 2006; M-G2	Hotel	Active	1	<i>C. hemipterus</i>
		7 Aug 2006; M-TP1	Hotel	Inactive	0	-
		14 Sep 2006; M-SI1	Hotel	Active	2	<i>C. hemipterus</i>
		14 Sep 2006; M-SI2	Hotel	Active	2	<i>C. hemipterus</i>
		14 Sep 2006; M-SI3	Hotel	Active	1	<i>C. hemipterus</i>
		14 Sep 2006; M-RI1	Hotel	Active	1	<i>C. hemipterus</i>
		14 Sep 2006; M-RI2	Hotel	Active	1	<i>C. hemipterus</i>
		14 Sep 2006; M-JM	Hotel	Active	1	<i>C. hemipterus</i>
		15 Sep 2006; M-MU1 α	Hotel	Active	1	<i>C. hemipterus</i>
		15 Sep 2006; M-MU2 α	Hotel	Inactive	0	-
		15 Sep 2006; M-MU3	Hotel	Active	1	<i>C. hemipterus</i>
		15 Sep 2006; M-MU4	Hotel	Active	1	<i>C. hemipterus</i>
		15 Sep 2006; M-TP2	Hotel	Active	1	<i>C. hemipterus</i>
		15 Sep 2006; M-TP3	Hotel	Inactive	0	-
		9 Nov 2006; M-MU5	Hotel	Inactive	0	-
		9 Nov 2006; M-MU6	Hotel	Inactive	0	-
		9 Nov 2006; M-SI4	Hotel	Inactive	0	-
9 Nov 2006; M-SI5	Hotel	Inactive	0	-		
11 Dec 2007; M-KJ	Residential house & flat	Active	2	<i>C. hemipterus</i>		
11 Feb 2008; M-CC	Hotel	Active	5	<i>C. hemipterus</i>		

Table 1 continued

Table 1 (continued). Bed bug collection sites in Malaysia and Singapore, species found, and the severity of infestations (n = 54 sites).

Country	City	Collection Date & ¹ Code	Premises	Infestation Status	² Infestation severity rank	<i>Cimex</i> Species
Malaysia	Kuala Lumpur	3 May 2008; M-QH1	Hotel	Active	1	<i>C. hemipterus</i>
		3 May 2008; M-QH2 β	Hotel	Active	1	<i>C. hemipterus</i>
		3 May 2008; M-QH3 β	Hotel	Active	1	<i>C. hemipterus</i>
		3 May 2008; M-QH4	Hotel	Active	4	<i>C. hemipterus</i>
		3 May 2008; M-QH5	Hotel	Active	3	<i>C. hemipterus</i>
		3 May 2008; M-CP1	Hotel	Active	3	<i>C. hemipterus</i>
		3 May 2008; M-CP2 γ	Hotel	Active	2	<i>C. hemipterus</i>
		3 May 2008; M-CP3 γ	Hotel	Active	2	<i>C. hemipterus</i>
		3 May 2008; M-CP4	Hotel	Active	3	<i>C. hemipterus</i>
		3 May 2008; M-CP5	Hotel	Active	3	<i>C. hemipterus</i>
		4 May 2008; M-GS1	Hotel	Active	2	<i>C. hemipterus</i>
		4 May 2008; M-GS2	Hotel	Active	3	<i>C. hemipterus</i>
		4 May 2008; M-GS3	Hotel	Active	4	<i>C. hemipterus</i>
		4 May 2008; M-GS4	Hotel	Active	4	<i>C. hemipterus</i>
		4 May 2008; M-GS5	Hotel	Active	1	<i>C. hemipterus</i>
		4 May 2008; M-GS6	Hotel	Active	1	<i>C. hemipterus</i>
		4 May 2008; -GS7	Hotel	Active	3	<i>C. hemipterus</i>
		6 May 2008; M-PL	Hotel (budget)	Active	5	<i>C. hemipterus</i>
Singapore	Singapore	1 Aug 2005; S-BB	Worker quarter	Active	N.A.	<i>C. hemipterus</i>
		5 Aug 2005; S-SL	Residential house & flat	Active	1	<i>C. hemipterus</i>
		10 Aug 2005; S-SA	Residential house & flat	Active	2	<i>C. hemipterus</i>
		17 Aug 2005; S-WD	Residential house & flat	Active	N.A.	<i>C. hemipterus</i>
		18 Aug 2005; S-LS	Residential house & flat	Active	N.A.	<i>C. hemipterus</i>
		11 October 2005; S-PR	Residential house & flat	Active	2	<i>C. hemipterus</i>
		8 Mac 2008; S-UN2	Residential house & flat	Active	2	<i>C. hemipterus</i>

¹Initial letter represents the country code; the letters after the dash indicate the sampling premise code, different rooms in hotels are indicated by different numbers after the premise code, and the same symbol after numbers indicates contiguous rooms.

²Infestation severity rank (number of bed bugs found): 0: none; 1: 0–10; 2: 11–20; 3: 21–30; 4: 31–40; 5: >40.

Table 2. The distribution frequency of active harborage sites infested by the tropical bed bug, *Cimex hemipterus*, in Malaysia and Singapore (n = 54 sites).

Harborage site	Distribution frequency (%)	¹ Infestation index
Bedding (including mattress, bed sheet, bed frame & pillow)	31.09	1.00
Headboard	30.25	0.97
Wall & floor (baseboard, cracks & crevices)	23.53	0.76
Sofa cushion	4.20	0.14
Rattan chair	2.52	0.08
Other wooden furniture	4.20	0.14
Others (including electric box, vacuum cleaner, etc.)	4.20	0.14

¹Infestation index = distribution frequency/highest distribution frequency.

warmer climatic region and observed that all identified specimens of *C. hemipterus* came from the warmer area of Queensland. In addition, this species was identified as the second largest group of hematophagous arthropods in a surveillance report of the Kikwit Democratic Republic of the Congo in 1995, with more than 9,000 specimens collected per month (Reiter et al. 1999).

Our study of 54 infested sites indicated that 74.1% and 25.9% of the infestations occurred in hotels and residential premises, respectively. Hwang et al. (2005) reported that single-family dwellings (49%) and apartment units (23%) were the top two locations treated for bed bug infestations in Toronto, Canada, in 2003. King et al. (1989) reported the discovery of severe infestation (involving thousands or more bed bugs) by environmental health officers in a flat in Islington, Britain. Many hotels and other public accommodations also are infested by bed bugs (Cooper 2006, Doggett 2006, Doggett et al. 2003, Myles et al. 2003, Owen 2004, Potter 2006, Ryan et al. 2004). These reports agree with our observations in this study.

No significant difference was detected between the severity of infestation in public and residential premises (Mann-Whitney test, $z = -1.200$, $P > 0.01$). The number of harborage types per infested room was positively correlated ($P < 0.05$) with the severity of infestation (Spearman rank correlation, $r_s = 0.350$). The coefficient of correlation, however, was low, indicating that other factors, such as duration of infestation and human activity, may also be determinants in the infestation. Compared to *C. lectularius* infestations, which can reach several hundred to thousands of individuals in an infested location, the relatively low infestation of *C. hemipterus* observed in most of the premises studied herein (< 30 bed bugs) is not unusual. Unlike *C. hemipterus*, *C. lectularius* is more efficient in obtaining blood meals and thus is able to achieve higher

levels of infestation (Araujo et al. 2009).

Bedding (31.1%), the headboard (30.3%), and cracks and crevices along the baseboard, wall, and floor (23.5%) were the top three most prevalent locations infested by *C. hemipterus* in our survey (Table 2). This observation concurs with Hwang et al.'s (2005) report that bedding (including the bed frame, mattress, and sheets) was the most frequently infested location. Through surveys conducted by pest management professionals, Gangloff-Kaufmann et al. (2006) found that bed bugs frequently inhabit the mattresses (98.2%) and box springs (93.6%).

Further dissection of the results indicated that the headboard (39.56%) was the most common location infested by bed bugs in hotels and public accommodations in Malaysia and Singapore, followed by the bedding (28.6%) (Table 3). In contrast, bedding (39.3%) was the predominant location of infestation of *C. hemipterus* in residential premises. These discrepancies in the location of infestation could be due to the housekeeping practices in hotels and public accommodations, where the mattress and bed sheets are frequently changed, cleaned, and even shifted from room to room. Kells (2006) reported that this practice may further disperse the spread of bed bugs and cause irregular patterns of infestation.

In residential premises, sofa cushions (14.3%) and rattan chairs (10.7%) were also common locations of infestation (Table 3). These sites, however, were not commonly infested in hotels and public accommodations. As ectoparasites, bed bugs spend most of their time in concealed harborage sites that are close to the host (Boase 2004, Mallis 1990, Potter 2006, Usinger 1966). They are capable of following their host and moving from one location to another (e.g., from bedroom to living room, from house to adjoining house, or from room to adjoining room in hotels and living quarters). Bed bug infestations have been reported in public transporta-

Table 3. The distribution frequency of active harborage sites of *Cimex hemipterus* in public and private accommodations.

Harborage Site	Public Accommodation		Private Accommodation	
	Distribution frequency (%)	¹ Infestation index	Distribution frequency (%)	¹ Infestation index
Bedding (including mattress, bed sheet, bed frame & pillow)	28.57	0.72	39.29	1.00
Headboard	39.56	1.00	–	–
Wall & Floor (baseboard, cracks & crevices)	25.28	0.64	17.85	0.45
Sofa Cushion	1.10	0.03	14.29	0.36
Rattan Chair	–	–	10.71	0.27
Other Wooden Furniture	3.30	0.08	7.14	0.18
Others (including electric box, vacuum cleaner, etc.)	2.20	0.06	10.71	0.27

¹ Infestation index = distribution frequency/highest distribution frequency.

tion, such as in airplanes (Whitfield 1939), ships (Boase 2004), and vans (Potter 2006), and theatres as well (Mallis 1990). Kells (2006) reported that the human environment provides an infinite number of habitats for bed bugs. Many of these habitats (especially those that are more permanent in nature, such as residential premises) may serve as a major reservoir for the pest. On the other hand, hotels and public accommodations are good examples of converging and diverging points of bed bug infestation.

Hypothetically, information about distribution frequency may indirectly demonstrate the route of bed bug movement in an infested premise. In hotels and public accommodations, the route is more direct compared to that of residential premises. The infestation indices (Tables 2 and 3) calculated in this study provides information that may be used to track the route of bed bug movement. We assumed that bed bugs disperse from the harborage site with the highest frequency to the other harborages with lesser numbers.

The headboard or bedding is probably the point of initial infestation, based on the highest frequency of infestation. From this location, bed bugs likely move to cracks and crevices along the baseboard, wall, and floor, and then spread towards the furniture. In residential premises, however, the route of movement is more diverse and varied due to the degree of activity and potential harborages within the premises. For example, in our survey we observed great numbers of bed bugs inside an old unused vacuum cleaner in a house that was infested for more than four years. Pfister et al. (2009) reported that bed bugs disperse when conditions are no longer favorable. This premise supported our observation that live bed bugs were found scattered on the walls and floor within several days after a pyrethroid

insecticide treatment (unpublished data).

In summary, *C. hemipterus* was the only species of bed bug found in Malaysia and Singapore in our survey. The headboard and bedding were the most common locations of infestation in hotels, public accommodations, and residential premises. These common locations of infestation should be thoroughly examined when conducting any bed bug inspection.

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