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Characteristics of bed bug (Hemiptera: Cimicidae) infestations in the metropolitan region of São Paulo, Brazil, between 2004 and 2009

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ABSTRACT

Bed bugs are blood-sucking insects belonging to the Cimicidae family. Some species are important in the context of public health because of their anthropophilic behavior. Currently, there has been a resurgence of bed bug infestations in various locations around the world, especially in large cities. The objective of this study was to describe the current state of bed bug infestations in the metropolitan region of São Paulo in the period 2004 to 2009. Through descriptive study based on records of occurrence of bed bugs provided by private pest control and government surveillance agencies in the Metropolitan Region of São Paulo, we registered 369 infestations of bed bugs. *Cimex lectularius* was the predominant species, accounting for 262 records (92.2%). The study revealed that bed bug infestations occur regularly in the metropolitan region of São Paulo. Underreporting of infestation is a reality, which minimizes the importance of the situation. The study revealed that bed bug infestations occur regularly in the metropolitan region of São Paulo.

KEYWORDS: Cimicidae, bed bug, infestation, São Paulo

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ABREVIATIONS

MASP, metropolitan area of São Paulo; APRAG, Association of Urban Pest Controllers; ADESP, Association of Pest Controllers Companies of the State of São Paulo; USA, (United States of America); IPM, integrated pest management; DDT, Dichloro-Diphenyl-Trichloroethane

INTRODUCTION

Bed bugs are wingless bloodsucking insects of small size, with body length ranging from 4.5 to 7.0 mm [1, 2]. Historically, two species have close association to man, being: *Cimex lectularius* Linnaeus, 1758, the common bed bug and *Cimex hemipterus* (Fabricius, 1803) the tropical bed bug [3]. Normally, these insects take refuge in a dry location with minimal lighting and air flow, such as pallets of beds and mattresses, cracks on the walls, carpets, inside suitcases etc. [4, 5, 6]. They stay in these shelters during the period of feeding inactivity, which corresponds to most of the day, emerging only at night to feed [7, 8, 9].

After about 40 years with very few records of these insects, there are indications that the populations of bed bugs are re-emerging throughout the world [5]. Interestingly, current events have characteristics that differ from those in the past. New occurrences are no longer restricted to areas with low social or health

status, they are also expressed in neat facilities that, however, generate large flows of people such as hotels, hospitals, theaters, cruise ships and airports [10, 11, 12]. In Brazil, the nuisance created by the infestation of bed bugs was not considered a relevant factor to justify mandatory notification in a surveillance system and therefore there is no official information on its occurrence.

The purpose of this study is to describe the current state of bed bug infestations in the metropolitan area of São Paulo (MASP) in the period from January 2004 to December 2009.

MATERIALS AND METHODS

This study was conducted in the metropolitan region of São Paulo (MASP). This region is composed of more than 38 municipalities, besides the municipality of São Paulo. The MASP is among the five largest urban agglomerations in the world with 19,917,608 inhabitants distributed over a land area of 7,943.82 km² [13].

To gather the information, infestation records of bed bugs in the MASP that occurred between January of 2004 and December of 2009 from 78 private companies of pest control associated with APRAG (Association of Urban Pest Controllers) and/or ADESP (Association of Pest Controllers Companies of the State of São Paulo) were used. Records from 43 public institutions that work on the research, identification, surveillance and/or control of insects and vectors were also used.

Collaborating companies and institutions received a data collection form to be filled with information they would have on their records about bed bug infestations. The correct completion of the form was detailed to all employees. The following information was registered for later analysis:

- Address of the occurrence;
- Date of the Event;
- Complainant: classified as residential property (house, apartment) or commercial and/or service establishment (hotel, cinema, nursery school, etc.);
- Correct identification of where the insect was found (bedroom, kitchen, living room, bed, sofa, etc.);
- Field collection and identification of the specimen(s). The identification was only considered when field collection occurred. Thus, one variable was dependent on the other.
- Degree of infestation. To set this degree we adopted the following nomenclature:
  - ⇒ Incidental encounter - meeting small number of adults in a single focus;
  - ⇒ Low infestation - meeting small number of adults and nymphs in only one focus;
  - ⇒ High infestation - finding numerous adults and nymphs in more than one focus of infestation.
- Control actions: chemical measures (insecticides), non-chemical (no use of chemical products during treatment) or aggregation of both, called integrated management.
- Results: satisfactory (the infestation was controlled) or recurrence (there was re-infestation, requiring additional control actions).

The variables described above were analyzed separately, defining the distribution and frequency, in percent, of each one of them.

RESULTS

The data obtained was, in general, heterogeneous, since form filling rate of each variable had a high disparity. While some variables have been met in 100% of records reported, other variables had a much lower proportion of filled data, not exceeding half of the records returned, limiting a more accurate analysis of the data.

A total of 369 occurrences of bed bug infestations were recorded in the MASP, and 269 were provided by public institutions, representing 72.9% of the records. Eleven public institutions (25.6% out of the 43 that took part in this study) were responsible for the public data, specially the Zoonosis Control Center of São Paulo, which provided 239 records (representing 88.9% out of 269 public data). Private pest control companies accounted for 27.1% (N = 100) of the records and these were provided by 26 different companies (33.3% out of the 78 that took part in this study).

Spatial distribution

Of all the records, 325 are in São Paulo (88.1%) and 44 are from neighboring districts (11.9%). From the 39 existing districts in the metropolitan region, 17 (43.6%) reported at least one record (Table 1).

Annual distribution

Generally, the number of records showed a significant increase of 64% between 2004 and 2009. Private companies' records showed a gradual and steady increase, while those reported by public institutions showed more variations (Figure 1).

Table 1. Distribution of the number and frequency (%) of bed bug records by district. MASP, 2004 to 2009.

District	Total	
	N°	%
São Paulo	325	88.07
Guarulhos	9	2.44
Barueri	8	2.17
Santo André	5	1.35
Diadema	3	0.81
Ferraz de Vasconcelos	3	0.81
Francisco Morato	2	0.54
Franco da Rocha	2	0.54
Mogi das Cruzes	2	0.54
Osasco	2	0.54
Santana de Parnaíba	2	0.54
Carapicuíba	1	0.27
Cotia	1	0.27
Embu	1	0.27
Jandira	1	0.27
Salesópolis	1	0.27
São Bernardo do Campo	1	0.27
Total	**369**	**100**

In summer, 135 (36.6%) records were obtained, 121 (32.8%) were obtained in spring, 71 (19.2%) in autumn and 42 (11.4%) in winter. Thus, bed bug events were more frequent in seasons with more pronounced average temperatures (spring and summer), summarizing 69.4% of the total records.

According to the monthly distribution, the records were concentrated in warmer months, October to March, with 261 occurrences (70.7%). June, July and August, the coldest months of the year, accounted for only 39 occurrences (10.6%) (Figure 2).

Complainant agent

Only 270 records had the complainant agent data filled properly in the form. From this number, 182 (67.4%) bed bug events occurred in residential establishments and 88 (32.6%), in commercial and/or service establishments.

Among the residential establishments, 116 records (64.1%) occurred in houses and 62 (34.3%) in apartments. Housing units accounted for 7% of the residential events.

Among the commercial and/or service establishments, the most representative gathering was the hostels for homeless care and hosting service establishments (hotels, hostels and student hostels) (Table 2).

Locations where the specimens were found

Among the 187 records that indicated the locations where the insects were detected, 77 (41.2%) reported that the meetings were restricted to only one piece of furniture and 110 (58.8%) records stated that they were present in more than one room or piece

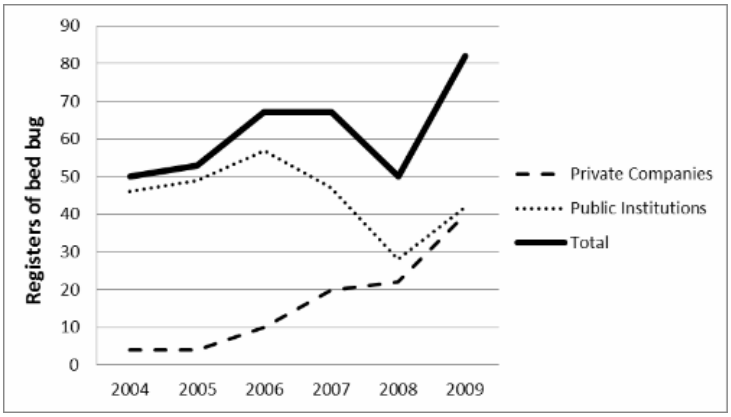

Figure 1. Distribution in the number of registers of bed bugs by year and data source. MASP, 2004 to 2009.

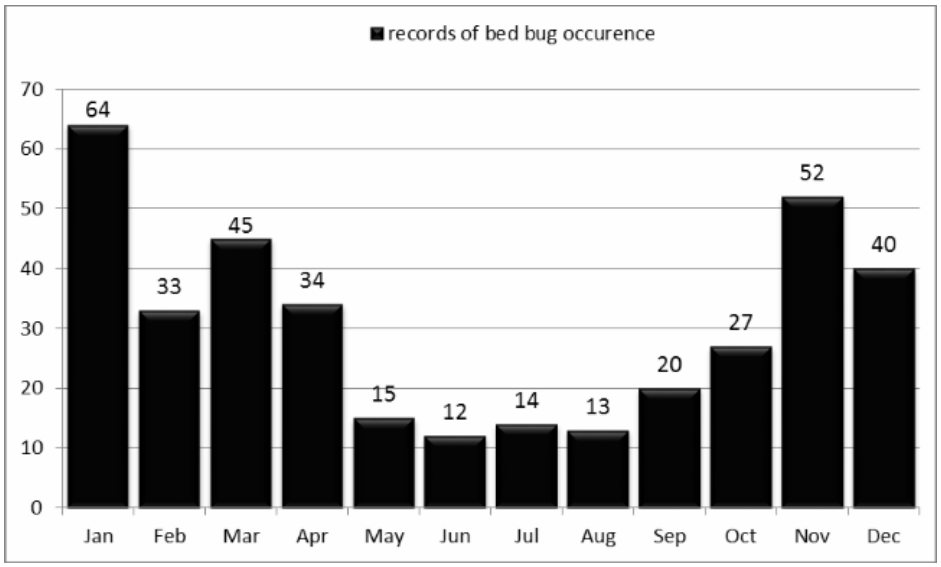

Figure 2. Distribution of bed bug occurrence records by month of the year. MASP, from 2004 to 2009.

Table 2. Distribution of the number and frequency (%) of bed bug records according to the complainant agent. MASP, from 2004 to 2009.

Complainant agent	Total	
	N°	%
Houses	116	43.0
Apartments	62	23.0
Hostels for homeless	39	14.4
Hosting services	22	8.1
Residences without specification	4	1.5
Day care centers	4	1.5
Housing units	3	1.1
Movie theaters	3	1.1
Prisons	3	1.1
Others commercial and/or service establishments	14	5.2
Total	**270**	**100**

of furniture. 15 specific locations, totaling 287 different locations, were recorded. The number of infested sites exceeds the number of records because in 77 of them there was more than one place infested (Table 3).

Only 18 (9.6%) of 187 records did not suggest the bed and/or its appendages as a point of detection of bed bugs. Therefore, in our study, bed bugs had clear preference for beds since 65.9% of the records were found either in the bed or on its frame, mattress and bed clothing.

Specimens collection and identification of bed bug species

Specimen collection was performed in 284 events (77.0%), 78 records (21.1%) stated that no collections were carried out and 7 records (1.9%) didn't provide information about this data. Frequency of collection was higher among public institutions (96.6%). Among private companies that rate was 24.0%. *C. lectularius* was the predominant species, accounting for 262 records (92.2%). On the other hand, *C. hemipterus* was collected in only one

event (0.4%), by a private company, in the city of Santo André. Eight records (2.8%) reported only *Cimex* sp. and 13 records (4.6%) sated the collection but there was no identification of species.

Degree of infestation

High level of infestation was predominant, with 50 occurrences (53.19%). Low infestations were sated in 35 records (37.23%) and 9 events were classified as an incidental encounter (9.57%).

Control action protocols and results

Only 69 records (18.7%) reported the control action protocols. Chemical methods (insecticides) were the most commonly employed, as mentioned in 49 records (71.0%). Associated management protocol was recorded 20 times (29.0%) and non-chemical management was not reported.

The result achieved by the proposed control action was stated in 40 records, being 21 (52.5%) satisfactory and 19 (47.5%) with recurrence of infestations.

Table 3. Distribution and frequency (%) of bed bugs by location. MASP, from 2004 to 2009.

Location	N°	%
Bed frames	115	40.1
Mattresses	71	24.7
Footers carpet	27	9.4
Cracks in walls and floors	26	9.1
Cabinets	19	6.6
Sofas and armchairs	16	5.6
Sheets	3	1.0
Others*	10	3.5
Total	**287**	**100**

*door frames, wooden boxes, curtains, electrical wiring, toys, plugs, rugs.

From Table 4 it is possible to note that, among the 40 records that informed the control action results, the proportion of satisfactory results decreased as the level of infestation increased.

DISCUSSION

Spatial and temporal distribution

It is possible to note that 43.6% of the cities studied had at least one bed bug record. Bed bug infestation was notified by nearly one third of the institutions that took part in this study and infestations occur in a scattered way in the MASP, not being restricted to few districts. Despite that, general population is still not well aware of the existence of these insects, and infestations are not being properly registered by the control authorities.

Private companies reported fewer events compared to the public institutions. However, the prevalence of these occurrences was higher in the private companies (33.3%) than it was in the public institutions (25.6%). Other authors reported a prevalence of 59% among pest control companies of Toronto (Canada) in 2003 [11] and 72% on the island of Oahu (Hawaii) in 2007 [14]. These values are higher than those found in this study, indicating the possible existence of severe underreporting of bed bug infestations in the MASP. Counting all the organizations that took part in this study, there was a 30.6% prevalence of occurrence of bed bug infestations.

Infestations in the MASP showed a significant increase in absolute numbers, between 2004 and 2009. This short period makes it difficult for a deeper analysis on the upward or downward trend in the number of records, since there are no known reliable data on the occurrence of bed bug infestations in the MASP prior to 2004, other than informal reports of events, conducted by

Table 4. Control actions results according to the level of infestation. MASP, from 2004 to 2009.

Infestation level	Satisfactory		Recurrence		Total	
	N°	%	N°	%	N°	%
Incidental encounter	2	100	0	0	2	100
Low infestation	13	81.25	3	18.75	16	100
High infestation	6	27.27	16	72.72	22	100
Total	**21**	**52.5**	**19**	**47.5**	**40**	**100**

entomologists at universities or research centers and surveillance. Amongst professionals from private companies such reports were even rarer.

The highest number of records in 2009 (N = 82) may reflect an increased attention by private companies to suspected infestations due to the fact that they were contributing to this study. Among public institutions, however, there was no clear trend of growth in the number of infestations, despite the significant increase in registrations between 2008 and 2009. It is possible that, in these institutions, taking part in this study did not affect the care given to suspected cases. That could have happened because of limited resources inflow or because those services already have well established routine services and the installation of a new process could only be absorbed gradually.

In countries where bed bug infestations have become more consolidated, the record of these events are reported in a systematic and scientific way, as in Germany [15], Canada [11] South Korea [16], Denmark [17], United States (USA) [18, 19, 20, 21, 22] and England [23], allowing authorities to build more complete statistical banks on them, which is not yet a reality in our country. According to the Toronto Urban Development Services Policy & Research, the Toronto district had a rate of 33.9 cases per 100,000 in 2003. In San Francisco (USA), the rate was about 40.3 cases per 100,000 inhabitants [24]. For comparison, in the city São Paulo, the year of the largest sample of infestations (2009) had 67 records, with a population of approximately 11 million inhabitants [13]. These records represent a rate of 0.6 cases per 100,000 inhabitants.

Although there are records for every months of the year, bed bug infestations tended to be more abundant in the months with more pronounced average temperatures (from October to March). This seasonal distribution is well known for other insect species also considered as urban pests, this is expectable because higher temperature favors the reproduction and accelerates insect development [25]. Still, there are few seasonality studies for bed bug infestations, mainly in tropical countries.

The seasonal changes in temperature may not be of so much importance for the biology and behavior of these insects when they are accommodated in shelters inside habitations, where the temperature remains uniform throughout the year [1, 4]. This can occur in temperate countries where the use of heating or other methods of indoor heating is common, especially in winter, keeping the low temperatures at acceptable levels for the development of insects throughout the year [26].

However, in tropical countries, such as Brazil, the habit of artificially warming the indoor environment is neither usual nor extremely necessary. Because of that, in these countries, especially in regions with relatively abrupt changes in temperature during the year, as the MASP, seasonality of bed bug infections may present more frequently, as reported in the city of Sydney (Australia), with more records in the warmer months [27]. Recently, however, some authors have also reported a seasonal pattern in temperate countries, such as USA [10], Denmark [17] and England [28].

Complainant agent, biotope occurrence and the locations where specimens were found

In the long period that followed between the dramatic control of infestations in the 1940s and 1950s until its reemergence in the 1990s, the presence of bed bugs had always been linked to prisons, nursing homes, hostels for the homeless and houses in poor condition. In USA, in the 1950s, bed bugs were found mainly in hostels for the homeless and prisons, but rarely at home [29]. Over time, bed bugs have begun to change their environmental preference, being found more easily inside habitations [23]. Actually infestations are found in a great variety of sites, habitations being the most affected sites, followed by hotels and hostels for homeless people [11, 14].

The infestations in the metropolitan region of São Paulo were recorded in a wide variety of environments, demonstrating the adaptability of bed bugs. In our study, most of the records also pointed out the habitations, may that be houses or apartments, as the most common, accounting for 68.0% of the records. Infestations were also detected in a wide range of commercial and/or service establishments. Although most of these records have been made in hostels (14.7%), hosting services also presented an important percentage (8.3%). Additionally, cinemas, nurseries,

prisons, office buildings, a health clinic and a hall for events, among others, reported at least one infestation in the present study.

No attempt was made in determining infestation prevalence among hostels for homeless people in the metropolitan region, but the high frequency with which these establishments were identified in the region, combined with information obtained in another study [11], sheds light on a public health problem, still unnoticed by the authorities, that represents potential risks of expanding. This might happen because populations of bed bugs can disperse easily from one hostel to another, they are benefited by the nomadic lifestyle of the homeless population, being transported by them in their clothes and belongings [11].

It is important to note that, although several authors have reported the hosting services (hotels and similar) as a major source of dispersal for bed bugs [23, 30, 31], few establishments admit the presence of an infestation in their premises, making it difficult to know the reality of infestation in those locations. In a rare study on this matter, it was reported that in Sydney, 79% of short-stay lodges reported infestations in the twelve months preceding the survey [27]. In the same context, regular residents often do not report infestations in their homes, fearing the old social stigma associated with the presence of a bed bug infestation, but also because of the high cost of control actions. Because of that, it is common that the population tries to control the infestations on their own, which is almost never possible.

Considering the location of the infestation, bed bugs were detected in different sites. The vast majority of these insects were recorded not only in beds (65.9%), but also in carpet footers (9.4%), cracks in walls and floors (9.1%), cabinets (6.6%) and sofas and armchairs (5.6%) were registered. This data shows bed bugs preference for locations near food sources or places where people can rest, sit or lie down for relatively long periods of time. In United States, in 2005 [32] and 2007 [33], a similar pattern was found, while in Indianapolis (USA) a lower prevalence of these insects in beds and couches (56%) was reported [34].

Typically, bed bugs avoid metal substrates, preferring wood or materials that can better maintain the temperature, such as textiles, cardboard and foam. However, it is possible that all inspections have been carried out by visual examination, not including the aid of auxiliary diagnostic methods, which may have compromised the ability to detect insects in less obvious places.

Specimens collection and identification of bed bug species

Only 24% of the private companies performed specimen collection while 96.65% of the public institutions collected samples of the bed bug infestation. However, among the institutions, it was observed that the collection was done mainly by the residents or establishment's claimants, accounting for 76.52% of samples taken, leaving the institutions with only 23.48% of the collections. In the private companies, 100% of the collections reported were conducted by a professional of the company. This information reflects the fact that in most cases, the finding of a bed bug infestation is not the result of domiciliary inspection programs, but the result of the initiative of their own residents to report an infestation within their homes [1].

Collection of specimens and their subsequent correct identification are fundamental steps to control an infestation. Results in our study show, however, that minor differences in technical procedures adopted by private companies and public institutions may exist. A further obstacle is the fact that most of the staff working in pest control private companies or in public institutions has had little contact with bed bugs, which may interfere in the correct detection of an infestation and, consequently, in the collection of the specimens and their correct identification. This difficulty, although it has not been measured in the study, was observed in the contacts made during the data gathering and is supported by reports made in other studies [35]. The adoption of professional training, aimed at the diagnosis of the infestation and at the taxonomic identification of insects of the Cimicidae family could minimize this obstacle.

It is clear that *C. lectularius* and *C. hemipterus* are sympatric in some regions of the world, as in Brazil and Africa [4]. However, according to our results, *C. lectularius* was widely prevalent in

262 records, while *C. hemipterus* was diagnosed in only one infestation. The dominance of *C. lectularius* in large urban centers and a greater presence of *C. hemipterus* in the neighboring districts, especially those with smaller population, would be expected [1]. The pattern found in our study may indicate underreporting of both species, but in a more pronounced degree of *C. hemipterus*.

Additionally, there is the possibility of misidentification, since, as mentioned earlier, staff in pest control centers might not have the expertise to identify bed bugs at the species level. This taxonomic problem has also been described in Australia [36]. In fact, countries that previously reported the presence of only one of these two species began to report the encounter of the other, nonexistent before. This was stated in Australia [36], Israel [37] and Thailand [38].

Degree of infestation, complainant agent, control actions protocols and their results

It is important to note that the classification applied in the degree of infestation was especially created for this study because other studies didn't use other similar gradients of classification. Consequently, this categorization may be subjected to some inaccuracies that future research with the same purpose can detect and correct. The most severe level of infestation, called high infestation, was predominant (53.2%), however, that does not mean it is the most common level of infestation. Infestations can take several months to be detected and in its early stages, the bed bugs tend to live in environments with little disturbance [39]. Therefore, the chances to diagnose the occurrence of higher degrees of infestation, with well established populations, are higher.

Due to the nocturnal habits, safeguarded behavior and the small size of these insects, the visual inspection is seldom flawless, not being able to identify all existent shelters, which can minimize the gravity of the situation. Additionally, few companies or institutions used effective tools in detecting and monitoring the shelters, which delays the real diagnosis of the situation and decrease the possibility of detecting infestations in their early stages. The attractive traps can capture more individuals than the visual inspection could actually predict and detect [34]. Severe infestations can also spread to other rooms or even other houses. This behavior often occurs when population levels become too high; bed bugs then establish a new shelter in another environment and remain incognito for several months [40].

As shown before, control actions with satisfactory results were more frequent when infestations were classified as "incidental encounter" (100%) or "low infestation" (81.25%), showing the greater difficulty of successful control actions when the infestation is presented in advanced stages. Controlling infestations at this stage is difficult, expensive and laborious [40, 41, 42]. Reoccurrence of the infestation was present in 52.5% of records reporting control action protocols. Other studies have also stated reoccurrence rates of 50% [40] and 57% [27].

The protocols being used today differ greatly from those used in the past, when these insects were common. The application of chemicals directly into the bed, trivial practice in those days, it is currently done very sparingly. Besides, after being the center of several ethical, medical and environmental debates, the indiscriminate use of chemicals is not recommended.

Nowadays, urban pests' management is species-specific, reducing the possibility of a bed bug infestation to be indirectly affected by actions aimed at other species, which also occurred with some frequency in the past. In addition, there are few data on the effectiveness of chemical compounds used today, and many professionals do not have the experience in dealing with these insects, it is common that during the process of control, some shelters are not identified and treated [5].

There are different non-chemical methods that can be used. Many of them are complex to implement, but other methods can be cheap and easy to handle. Among these methods, it is important to discuss the disposal of infested furniture. Often suggested as a last resort, because of innumerous previous attempts to control the infestation, this habit can contribute to bed bugs dispersion as the

new owner of the discarded furniture inadvertently take it into his residence. It is necessary to develop new techniques for integrated pest management (IPM) to control infestations. However, there is few data on costs to implement these strategies for the control of bed bug infestations [34].

As these insects remain for long periods in their shelter, it is recommended that the chemicals used have a good residual action, so that the bugs can come into contact with the product when they are foraging or returning to their shelters. As the active ingredients of the most common insecticides frequently belong to the same chemical class, the potential of acquiring resistance is great.

In Sri Lanka, after 25 years of DDT (Dichloro-Diphenyl-Trichloroethane) banishment, field populations still had high resistance to this compound. In this country, pyrethroids were introduced in 1994 to combat malaria mosquito vectors and only recently it began to be used for bedbugs. But even in this short time, bed bug populations have already started to show the first signs of resistance [43].

In fact, resistance to pyrethroids is already a reality described by several authors, including Brazil [44], USA [45] and England [46]. Furthermore, bedbugs have behavioral mechanisms that make them avoid direct contact with the active ingredients of insecticides.

CONCLUSION

In conclusion, the preset study shows that the bed bug infestations occurred regularly in the Metropolitan Region of São Paulo from January 2004 to December 2009. However, underreporting is likely to be occurring, minimizing the severity of the situation. Studies on the biology, behavior and ecology of the Cimicidae family and especially of *Cimex lectularius* are fundamental for a better control of the infestation. The installation of an entomological surveillance program is necessary in order to understand, monitor, detect and prevent infestations of these insects. In this context it is also important to seek the adoption of appropriate control measures, integrating professionals from private pest control companies and public institutions of surveillance and vector control and research.

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