

Full Length Research Paper

Diagnosis of Cimicidae, ectoparasites linked to human habitat in Côte d'Ivoire

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Bed bugs as ectoparasites of humans are expanding in the world. Their geographical distribution has undergone major changes, particularly in connection with the globalization of trade, the movement of travelers and the anarchic urbanization of major cities. Following repeated complaints and requests for disinsection, bed bug collections were carried out in the cities of Abidjan, Grand Bassam, Anyama, Agboville, Yamoussoukro, Bouaké and Guiglo. The objective of this study was to determine the species of this ectoparasite in Côte d'Ivoire, with a view to efficient control. Thus, two species were identified: *Cimex hemipterus* and *Cimex lectularius*. *C. hemipterus* appears to be more represented in infestations than *C. lectularius* at 77.9% (n=868). In the case of *C. lectularius*, it accounted for only 22.1% (n=246) of infestations in the surveyed locations. Fisher's test on the proportions of the two species revealed a highly significant difference (p<0.001) between them. Bed bugs are therefore present in Côte d'Ivoire and the dispersal of collection sites provides an overview of its geographic distribution. It also reflects a worrying health situation to which solutions must be found.

Key words: Diagnosis, Cimicidae, ectoparasites, Côte d'Ivoire.

INTRODUCTION

The main bugs are belonging to the Order Heteroptera, Family Cimicidae and Genus Cimex. They are hematophagous insects that have been living next to humans for thousands of years. They prick their host in his sleep with night-time manners and lucifuges (National Centre of Expertise on Vectors NCEV, 2015). The term bed bug refers to two globally known species for their

nuisance. They are: *Cimex lectularius* Linnaeus, 1758 and *Cimex hemipterus* Fabricius, 1803. In countries of Asia, America and Europe, these insects are a real public health problem. They are responsible for a numerous dermatological and allergic disorders they cause, ranging from a simple bite to generalized manifestations which can be linked to an urticaria. In addition, infestations of

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entire buildings (collective dwellings, hotels, retirement homes, hospitals, etc.) have been reported in these countries (Delaunay et al., 2015). Fortunately, bed bugs do not yet present a risk of transmission of infectious agents. However, the degree of nuisance is such that many countries (France, Belgium, the United States, etc.) have made the control of these insects a priority. In Côte d'Ivoire, the bed bugs were repeatedly reported in the service reports of the National Institute of Public Hygiene (NIPH); but were never formally identified. In urban areas, particularly in Abidjan, recurring complaints due to the activity of these bed bugs were reported by the Vector Control Service (VCS) of the NIPH. The nuisance they cause is of increasing concern, including the distribution of infestations, the conditions of mattress infestations and the extent of infestations. However, finding solutions to these concerns will necessarily involve identifying the agents responsible for these infestations. Knowledge about the biology and ecology of bed bugs is unfortunately almost non-existent in Côte d'Ivoire.

The purpose of this preliminary study was to identify the species of bed bugs that were implicated in the reported home infestations, with a view to establishing the first tools for finding a suitable control.

MATERIALS AND METHODS

Study area overview

This study was conducted in several cities of Côte d'Ivoire; country located in West Africa, in the intertropical wet zone of the earth, between the Tropic of Cancer and the Equator. Four study cities in the south of the country (Abidjan, Grand Bassam, Anyama and Agboville) and three collection sites in the center (Yamoussoukro and Bouaké) and in the west (Guiglo) served to collect the "bedbug" specimens studied (Figure 1).

Entomological surveys: capture of bed bugs

This was a cross-sectional survey that ran from August 2016 to February 2019.

Thus, in practice, the collection sites were visited only once, following a distress call indicating the probable presence of these insects. The sites visited were very diverse, including private homes, businesses, bus stations, hotels, places of worship, markets and hospitals. The method of collection consisted of searching during the day and by direct observation for signs of the presence of the bed bugs: eggs hatched or not, nymphs and brown molt skins, traces of blood on the sheets and excrement left. All places likely to harbor these insects, mainly mattresses, used clothing, used furniture and cracks in the wall, were carefully inspected. When these signs were visible, aerosol cans were used to flush out the bugs. After a few minutes of waiting, the dead or living insects were taken out of the hiding places and collected using an entomological clamp and kept in pill boxes containing 70% alcohol. Each pill box was labelled by sampling location and collection date. At the NIPH laboratory, the collected individuals were subjected to classical diagnostic techniques using binocular magnifying glass and dichotomous keys from Masini et al. (2019) and Benkacimi et al. (2020).

Data exploitation and analysis

Data was captured and organized from Microsoft Office Excel 2013. This spread sheet was used to calculate numbers and proportions of species observed. Fisher's nonparametric test was performed using the statistical software SPSS version 25. It was used to compare the proportions of different species caught at collection sites. The significance threshold was set at 5% ($p < 0.05$).

RESULTS

Following diagnosis, two species of bed bugs were identified (Figure 2a and b). These are *C. hemipterus* and *C. lectularius*. They were collected from all collection sites (Table 1). *C. hemipterus* and *C. lectularius* are very close morphologically, however, only the shape of the pronotum or medici neck can differentiate them.

A total of 1,114 bed bugs were sampled across even cities. Of the two species identified, *C. hemipterus* was the most frequent at the reported infestations, with 77.9% ($n=868$) and 22.1% ($n=246$) for *C. lectularius* (Table 2). Fisher's test on the proportions of the two species revealed a highly significant difference ($p < 0.001$) across all the cities investigated. In addition, *C. hemipterus* was the best represented species in each city. The proportions of this species recorded in Abidjan, Grand Bassam, Anyama, Agboville, Yamoussoukro, Bouaké and Guiglo were 77.1% ($n=475$), 78.1% ($n=89$), 71.7% ($n=43$), 75% ($n=27$), 83.9% ($n=73$), 77.3% ($n=102$) and 85.5% ($n=59$), respectively. A total of 46 harvests were conducted during this cross-sectional study (Table 2).

DISCUSSION

The bed bugs of the Family Cimicidae are very invasive hematophagous insects. Their geographical distribution has undergone major changes in connection with the globalization of trade, the movement of travellers and the anarchic urbanization of large cities. Of all the species of Cimicidae, *C. hemipterus* and *C. lectularius* are known worldwide for the nuisance they cause in human populations (Delaunay et al., 2011; Masini et al., 2019; Benkacimi et al., 2020).

C. hemipterus and *C. lectularius*, although present in Côte d'Ivoire, are very little known to scientists and the public. This is due to the lack of sufficient information on their bio-ecology but also because they are not vectors of pathogens to humans and animals. Although not vectors, laboratory studies revealed that these species host several infectious agents; these include bacteria (*Bacillus anthracis*, *Mycobacterium leprae*, *Mycobacterium tuberculosis*), parasites (*Trypanosoma cruzi*, *Wuchereria bancrofti*) and mushrooms (*Aspergillus flavus*) (Burton, 1963). However, the presence of *C. hemipterus* and *C. lectularius* in European, American and Asian continents, are a source of major concern (Balvín et al., 2014; Jourdain et al., 2016). The considerable financial

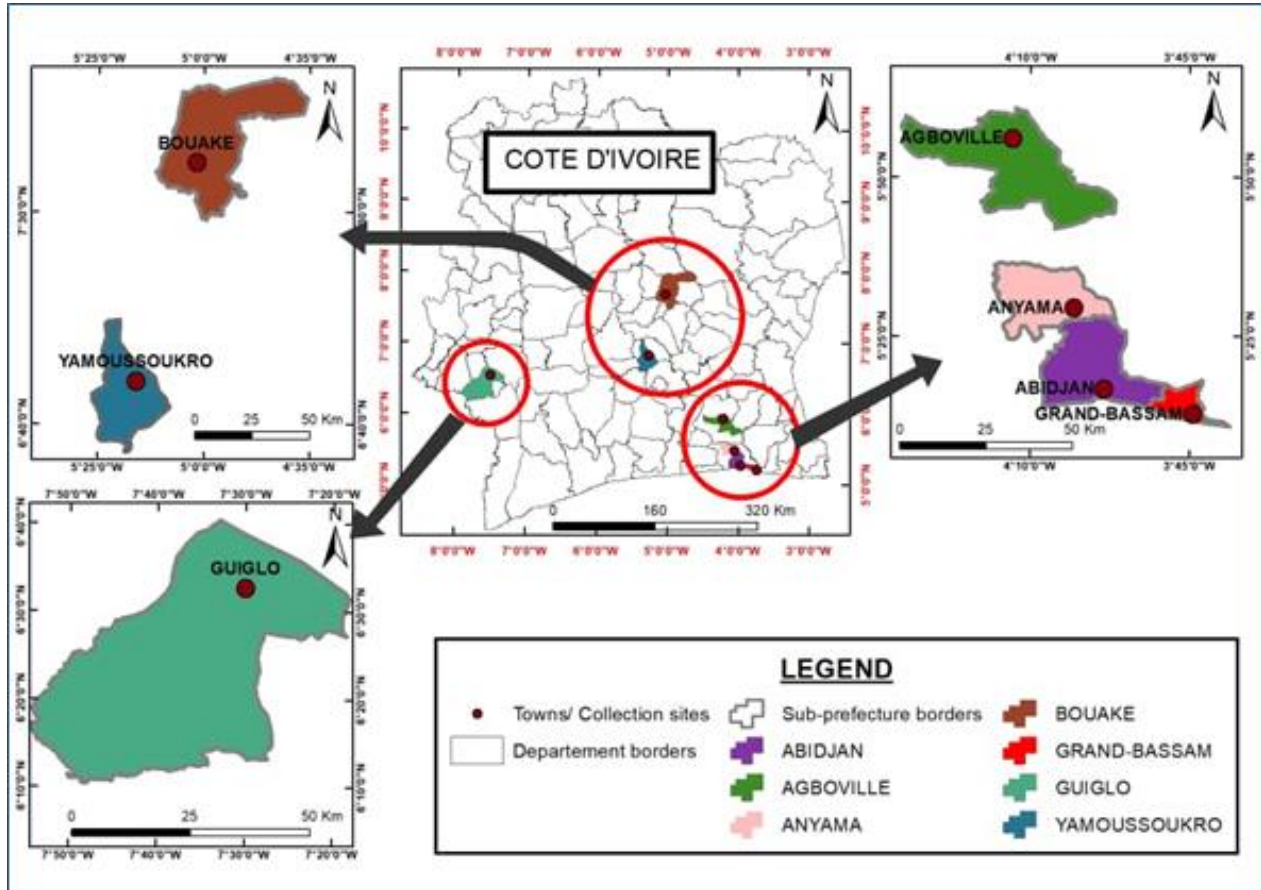


Figure 1. Distribution of study sites.
 Source: National Institute of Public Hygiene, Data 2016-2019



Figure 2. (a) *Cimex hemipterus*, (b) *Cimex lectularius*.
 Source: National Institute of Public Hygiene, Data 2016-2019

Table 1. Fauna of *Cimex* spp. at the different collection sites.

Collection sites	Species of bed bugs	
	<i>Cimex hemipterus</i>	<i>Cimex lectularius</i>
Abidjan	+	+
South		
Grand Bassam	+	+
Anyama	+	+
Agboville	+	+
Centre		
Yamoussoukro	+	+
Bouaké	+	+
West		
Guiglo	+	+

+: presence of the species

Source: National Institute of Public Hygiene, Data 2016-2019

Table 2. Population and proportions of bed bugs at collection sites.

Collection sites	Number of harvests	Total of species (%)		Fisher test
		<i>Cimex hemipterus</i>	<i>Cimex lectularius</i>	p_value
Abidjan	38	475 (77.1)	141 (22.9)	p<0.001
South				
Grand Bassam	2	89 (78.1)	25 (21.9)	p<0.001
Anyama	01	43 (71.7)	17 (28.3)	p=0.001
Agboville	01	27 (75)	09 (25)	p=0.001
Centre				
Yamoussoukro	02	73 (83.9)	14 (16.1)	p<0.001
Bouaké	01	102 (77.3)	30 (22.7)	p<0.001
West				
Guiglo	01	59 (85.5)	10 (14.5)	p<0.001
Overall total	46	868 (77.9)	246 (22.1)	P<0.001

Source: National Institute of Public Hygiene, Data 2016-2019

resources allocated to vector control programmes, the innovation tools (heat treatment devices) and the new methods of control are all examples of the situation prevailing in some countries on these continents. The economic impact of infestations is very important but difficult to quantify for individuals, the hotel industry and the tourism sector (Davies et al., 2012; NCEV, 2015). Indeed, individuals must face the high cost of pest control, replacement of infested furniture, bedding and clothing. For the hotel industry, the costs are much higher due to the unoccupied rooms of the contaminated rooms. This may have repercussions on the tourism sector. This is a huge shortfall for these countries (Davies et al., 2012).

In this study, the importance of the collection cities (Abidjan, Grand Bassam, Anyama, Agboville, Yamoussoukro, Bouaké and Guiglo) gives an overview of the geographical distribution of the bed bugs present in Côte d'Ivoire and, on the other hand, reflects a worrying health situation. *C. hemipterus* and *C. lectularius* being highly invasive cosmopolitan species, their expansion could be caused by two types of displacement: active and

passive. Active displacement is used to search for a blood meal as soon as individuals are present in the locality or in the infested sites. The second mode of movement requires the action of humans. Fortuitously, they transport the insects to new places located several kilometers away; when traveling, moving, bringing old furniture, books or second-hand items previously infested into one's home (Anastay et al., 2011; Delaunay et al., 2015). The latter is believed to be the main cause of the reported infestations.

C. hemipterus and *C. lectularius* are very close morphologically, however, only the shape of the pronotum or medici neck can differentiate them (Masini et al., 2019; Benkacimi et al., 2020). In this study, *C. hemipterus* (77.9%) was the most prevalent in the reported infestations. This reflects the ecological belonging of this species to the Ivorian territory, therefore to the tropical zone. Furthermore, it's dispersal is currently spreading beyond tropical borders due to the globalization of trade, travel, and the anarchic urbanization of major metropolises. There also is a modification of *C. lectularius* geographical area. Once

restricted to temperate regions, this species has adapted to new territories in Africa (Federica et al., 2013; Zorrilla-Vaca et al., 2015). This is very well illustrated by its small proportion (22.1%) obtained during the various entomological surveys.

To date, there is no single method of struggle in the world that can overcome or eliminate bed bugs. Most vector control programs face enormous challenges, including population adherence, resistance to insecticides and resurgence of infestation sites (Davies et al., 2012; Morand, 2014).

Control of these insects is rarely achieved through a single approach. Only an integrated approach would be realistic. The collaboration between occupants, owners and pest controllers is therefore essential for an effective and parsimonious fight. Also, further investigation of sites of pest predilection and transfer of pests from one site to another could contribute to a more efficient and reasoned management.

Conclusion

This study identified two species of bed bugs: *C. lectularius* and *C. hemipterus*; with a relatively high population for the latter. In addition, the importance of *C. hemipterus* in relation to *C. lectularius* means that they are both present in all the cities visited. This situation indicates that they are present in the south, the center and the west of the country. In view of this distribution, it seems urgent to point out the importance that these species of bed bugs could represent if nothing is done to control them.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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