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SWOT ANALYSIS OF INTEGRATED PEST CONTROL MEASURES USED IN BED BUG CONTROL IN COLOMBIA AND SPAIN

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Abstract This study aimed to assess the records and experience of Integrated Pest Control and Management Companies in Colombia and Spain to contribute to the epidemiological knowledge of bed bug infestations in both countries. To accomplish this objective, a confidential 27-question questionnaire, designed using Google forms®, was sent by different means: directly or through national associations (Vector and Pest Management and ACOPI in Colombia, and ANECPLA in Spain) and, in Colombia, a surveying company was used. The returned surveys were assessed using a Strengths, Weaknesses, Opportunities and Threats (SWOT) approach. More than 900 surveys were sent (from June 2021 to November 2021). Only 31 were returned: 17 from Colombia and 14 from Spain. Several similarities and differences were found; from the years of experience to the proportion of companies that had to intervene with bed bug infestations. Infestations requiring intervention occurred in urban, rural, and peri-urban areas and affected all social strata. In Spain, the number of companies that carried out several monitoring visits and gave information to the client about the know-how was higher, and the use of dogs and diatomaceous earth was only reported in this country. Infested places were differentially reported in both countries. In both countries the presence of inefficient insecticides was reported, although it appeared to be more severe in Spain. This study informs about the differences and similarities between the bed bug situation in Colombia and Spain, and thus reinforces the importance of the pest control companies and the creation of adequate protocols in their combat against the global resurgence of bed bugs.

Key Words *Cimex hemipterus*, *Cimex lectularius*, Insecticides, Infestation control, Survey.

INTRODUCTION

Bed bugs, especially *Cimex hemipterus* (Fabricius, 1803) and *Cimex lectularius* Linnaeus, 1758 (Hemiptera Cimicidae), have been accompanying humanity basically since its inception, and have traveled and evolved with humans ever since, becoming cosmopolites parasites (Doggett et al. 2018). They were considered basically eradicated in developed countries from the 1950s onwards, thanks to social, communitarian, and physical and chemical measures (especially insecticides). Even so, since the end of the twentieth century, a global synchronous resurgence of bedbugs (Zorrilla-Vaca et al. 2015, Doggett et al. 2018) have been documented. This highlights, alongside the long relationship between the species (Doggett et al. 2018), the difficulties in control and eradication (Ray 1971). Many of the modern methods of treatment and control were forged and originated in the multiple attempts to keep this pest under control (Doggett et al. 2018), in which Integrated Pest Control and Management Companies (IPCMCs) are important players. Due to the importance of these control measures and the fundamental roll that IPCMCs have in their implementation, the objective of this study was to assess the knowledge, practices, and opinions of Integrated Pest Control Management Companies regarding bed bug control in both Colombia and Spain.

MATERIALS AND METHODS

A confidential 27-question questionnaire was designed using Google forms® platform. The questions involved practices, methodology, beliefs, epidemiology and opinions regarding bed bugs and the management of such insects. This questionnaire had closed and open questions and was validated internally and externally. The sharing of such questionnaire was done by different means: they were sent directly, through secondary shares by people who answered the questionary, through different national associations such as Vector and Pest Management and ACOPI (Colombian Association of Micro, Small and Medium Companies) in Colombia and ANECPLA (National Association of Environmental Health Companies) in Spain. As well, in Colombia a surveying company (Team Research) was used. The returned surveys were assessed using a Strengths, Weaknesses, Opportunities and Threats (SWOT) approach as well as a qualitative approach. Graphs and figures were made with R version 4.1.2 ® (The R Foundation for Statistical Computing) using tidyverse, ggplot2, HH and RColorBrewer packages.

RESULTS AND DISCUSSION

Of the more than 900 surveys sent (approximately 500 in Colombia and 400 in Spain), only 17 surveys were answered in Colombia and 14 surveys in Spain. In these answers it was found that most companies had less than 20 people working on them, except three in Colombia that had 50 or more employees and one in Spain which had more than 80. Even with this low response rate, it is an important first approximation since IPCMCs are crucial and fundamental pillars of action in the control of these types of parasites. Due to the importance of such companies and institutions, it is fundamental to assess their experience and knowledge. Therefore, in several parts of the world efforts have been undertaken to achieve this objective. One of such contributions is this study. It was better than the one found by Jourdain et al. (2016) via e-mail, but it was inferior to response rate obtained through telephone contact in that study. Compared to the 31 responses obtained in the present study, the number surveyed by Jourdain et al. (2016) was 51, which was like the one assessed by Zulaikha and Majid (2016), which was 48, and much lower than the one analyzed by Mumcuoglu and Shalom (2010) which were over 140 companies. Even so results were similar.

It was found that IPCMCs from Colombia had in average 12.7 years of experience (SD ± 11.6 years) with a median of 10 years. In Spain, companies had in average 23 years of experience (SD ± 15.5 years), with a similar mean to the companies surveyed in Mumcuoglu and Shalom (2010). During these years of experience a great proportion of companies have had to intervene with bed bug infestations: it was found that 16 (88.2%) of the companies in Colombia had had to intervene this type of infestation (one does not currently work dealing with bed bugs); and in Spain a 100% of the companies that answered the questionnaire had to intervene this plague. During these interventions several strengths were found, these include: the use of several approaches to deal with the infestation at the same time (a multipronged approach), the use of thermic or chemical approaches, the teaching of the know-how to the affected patients, repetition of control measures, and several monitoring visits. For weaknesses, the fact that only some companies use several opportunities to monitor the affected establishments or residences, the lack of teaching the know-how to the affected patients, the use of only visual inspection, relying only in insecticides to treat the infestations, and the lack of post-treatment monitoring in the case of some companies. In Colombia, different to Spain, no sniffing dogs were used, and although these are important tools, they can have an important proportion of false positives even when certified (Pfiester et al. 2008). Also, diatomaceous earth was used in Spain but not Colombia. About these interventions, according to literature, a good approximation comprises 6 stages (Delaunay et al. 2010): 1) confirmation of bedbug infestation; 2) assessment of the level of said infestation; 3) non-chemical control; 4) judicious use of insecticides 10-15 days apart; 5) assessment of control actions; 6) advice and prevention, aspects that were lacking in the reported protocols of some of the surveyed companies. Although some companies reported post-treatment visits this was not the norm. These findings, regarding the protocol used by the surveyed companies, could have been due to the openness of the question, where companies could have decided to not go deep into their protocols. These findings were different from the ones found in France (Jourdain et al. 2016) and Israel (Mumcuoglu and Shalom 2010) where a greater proportion of companies reported such events.

Places And Social Strata Of Interventions

Regarding the areas of action (urban, peri-urban, and rural), companies in both countries had to intervened infestations in every single of those zones, although in Spain a greater proportion of companies did interventions in urban areas, whereas in Colombia interventions were more evenly distributed (Figure 1.). For both countries the definitions for urban, peri-urban, and rural areas were the same. In these areas, every single one social stratum was intervened, even when the way social strata are classified in both countries are different, and based on a completely different pattern, it can be said that all social strata can suffer the burden of this infestation, from the lowest social class to the highest social class. Which is compatible with literature and shows that bed bugs are not associated with class or possible sanitary conditions (Usinger 1966, Doggett et al. 2018).

Number Of Interventions In A Single Infestation And Abundance Of Bed Bugs

In Colombia, most companies had to intervene more than one time the same infestation: the majority had to intervene a maximum of 2 times, some 3 times and 1 had to intervene 5 times. On the other hand, the proportion of companies in Spain that reported this occurrence was higher, with a greater number of interventions in a single infestation, for example 1 company had to intervene ten-times a single infestation. Although most companies in both countries thought that these parasites were relatively common, companies in Spain tended to perceive a higher abundance of such parasites.

Rise In Number Of Infestations And Reasons

Regarding the possible rise of cases and infestations in both countries, according to IPCMCs opinion, in general the numbers of infestations have risen over time, with a key difference, some companies in Colombia thought that the number have remained stable, whereas in Spain none of the companies thought likewise. The situation in Colombia was reminiscent of the one found by Jourdain et al. (2016) where most companies thought they had risen, and some thought they had remained stable, but it was completely different compared to Spain were no company thought in the latter manner. The reasons for the rise in cases can be seen in Table 1. Other given reasons were: 1) international commerce; 2) lack of knowledge about bed bugs; 3) used furniture trading; 4) globalization; and 5) international travel with rise in number of travelers. These reasons were comparable to the ones found in published literature (Usinger 1966, Doggett, Miller et al. 2018), reasons that have their bases in changes in public health measures, type of insecticides, monitoring policies and lack of social and community approximations (Usinger 1966, Doggett, Miller et al. 2018)

Table 1. Reasons for resurgence and rise in infestations given by IPCMCs

Reason	Colombian Companies (%)	Spanish Companies (%)
Insecticide resistance	8 (47.1%)	7 (50%)
Foreign migration	7 (41.2%)	10 (71.4%)
Forced internal displacement (whether due to violence or economic displacement)	4 (23.5%)	3 (21.4%)
Lack of Vigilance	5 (29.4%)	2 (14.3%)
All	5 (29.4%)	1 (7.1%)

Insecticide's Effectivity, Methods Of Control, Affected Dwellings, Hiding Places And Number Of Interventions Per Year

For the insecticides and their effectivity, in both countries reports of ineffective insecticides, specially deltamethrin, were made. The difference is that in Spain, some companies reported that no insecticides were effective, but that using stablished protocols the infestation could be dealt with. These reports about inefficacious insecticides suggest the presence of resistant populations, specially to pyrethroids, which could be secondary to the cross resistance to DDT, which was used in Colombia several years ago for malaria and vectorial control and in Spain for control of pests including bed bugs (Servicio de Erradicación de la Malaria 1957, Busvine 1977, Doggett et al. 2018). Having said that, this study can be taken as a base for subsequent approximations. A widespread survey could be done from public health institutions to understand and to improve the way bed bugs and other pests are managed and find possible resistant populations. Even as this is the case, curiously and different to Spain, where every single company used alternative methods, in Colombia some companies did not use such alternative methods. These included closing holes, cracks, and fissures, heat, vapor, vacuuming, special mattress cover, traps, and diatomaceous earth.

During the control measures several hiding places were reported including mattresses, living room triplets, saloon, backpacks and bags, electric outlets, wallpaper, chairs, and armchairs, sleeping room, among many others. These results were comparable to what was found in other studies (Zulaikha and Hassan 2016), where bedbugs were found alongside walls, floors, and sofas. Regarding the dwellings where this companies reported working in the results were varied. In Colombia the most common places were nursing homes, migrants or displaced persons households and transit residences, in Spain they were private residences, hostels and hospices. Hotels, motels, and multi-tenant house have been reported as high risk for infestations (Mumcuoglu and Shalom 2010, Zulaikha and Hassan 2016), as well as private residences (Mumcuoglu and Shalom 2010), which were similar and different to the places that were found in the present study.

Ipcmcs Opinions Regarding Public Health Institutions Monitoring and Relative Importance Of Bed Bugs

Finally, regarding vigilance and monitoring, all the IPMCs in Colombia considered that bedbugs infestations should be monitored by the public health system. These companies gave several reasons: from the constant and important migration to possibility of pathogen transmission, establishing epidemiological maps and to prevent and monitored inefficacious eradications, among many others. The reasons given in Spain were similar although they add the recent resurgence, the effects they have on the affected populations, among others. Interestingly, some Spanish companies said that bedbug infestations should not be monitored by public health or statal institutions, the reasons for these responses were varied but included the relative importance of this pest compared to others and the lack of vectorial transmission (Figure 2).

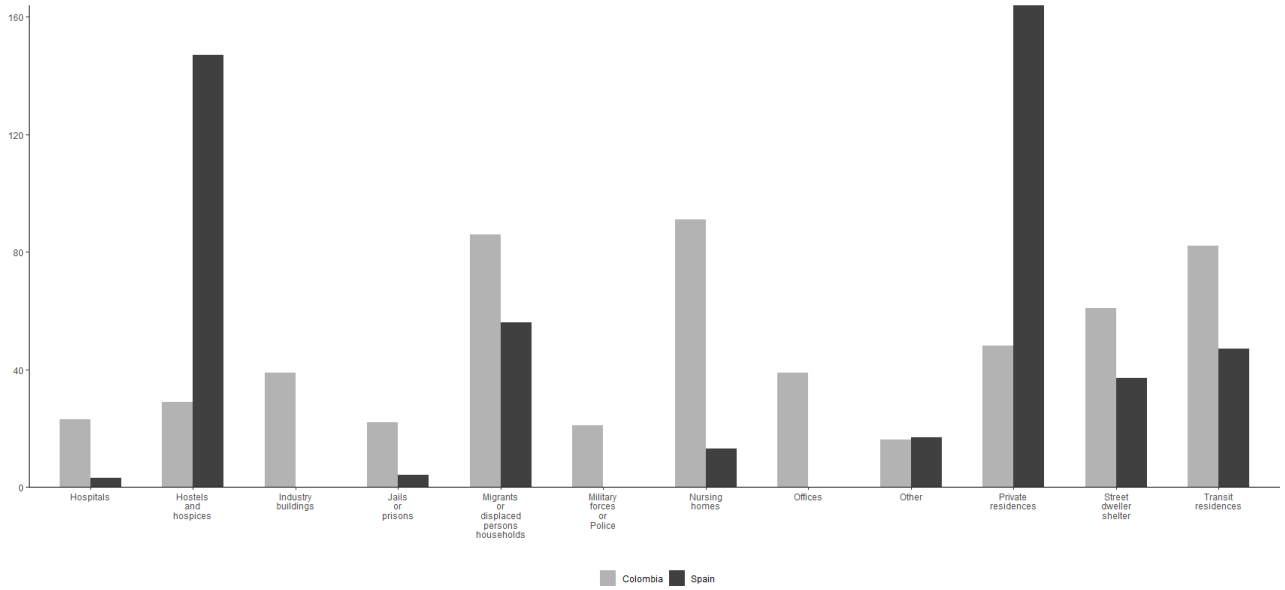

Figure 1. Places of Bedbug Interventions as Reported by IPCMCs

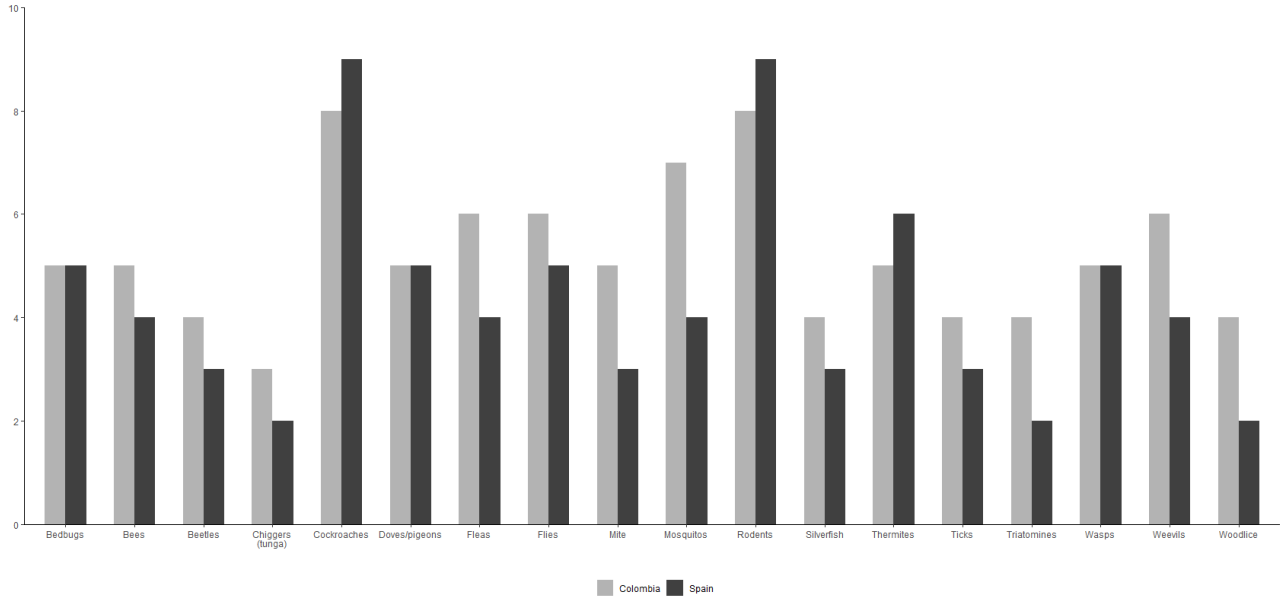

Figure 2. Relative Importance of Pests according to the Opinion of IPCMCs

Limitations

Even with all this findings, differences and similarities, the limitations of this survey are numerous, the first one is the small number of responses in both countries which precluded a geographical and quantitative approach, there is no weighting of the responses where a small company weights the same as a large company, bias due to the use of national associations leaving outside unaffiliated IPMCs, the fact that many contacted IPCMCs did not answer the survey and their opinions and protocols could be different, the fact that no questions regarding how the infestation was confirmed or how the level of infestation is assessed were made, and the fact that the results are based on personal responses and depend on the complete good faith of the respondents.

CONCLUSIONS

This study highlights the increasing importance of bed bug infestations in two related but different countries. It also reveals the different Strengths, Weaknesses, Opportunities and Threats of the different approaches to control and treat such infestations in both countries, and the opinions regarding the burden this pest causes in the population. As well, it shows differences in practices and opinions between the people who treat and intervene this plague. It highlights several opportunities of subsequent research and approximations, since knowledge regarding bed bugs in Colombia and Spain remain limited, especially in its distribution and burden, although it shows interesting differences between both countries.

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