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Entomology Insights OPEN ACCESS JOURNAL
DOI: https://dx.doi.org/10.17352/ei

Review Article

Bed Bugs and Human Health: A Global Review of *Cimex hemipterus* (Fabricius, 1803) and *Cimex lectularius* (Linnaeus, 1758) (Hemiptera: Cimicidae)

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Received: 18 November, 2025
Accepted: 25 November, 2025
Published: 26 November, 2025

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Keywords: Aggregation; Cimicidae; Hemiptera; Insecticide resistance; Morphology; Volatile organic compounds

Abstract

Cimex hemipterus (Fabricius, 1803) and *Cimex lectularius* (Linnaeus, 1758) (Hemiptera: Cimicidae) are globally significant pests, showing remarkable ecological adaptability, medical relevance, and increasing resistance to commonly used insecticides. This review synthesizes updated knowledge on their morphology, biology, life cycle, feeding behavior, and chemical communication, with emphasis on the comparative analysis between temperate and tropical species. Morphological traits such as pronotal expansion, setae distribution, and antennal proportions remain essential for species identification, particularly in regions where both species coexist. Biologically, bed bugs exhibit rapid population growth under optimal temperatures and rely on specialized mouthparts and hematophagy, which contribute to dermatological reactions including papules, pruritus, and, in rare cases, anemia. Insecticide resistance has expanded across pyrethroids, neonicotinoids, and mixed formulations, driven by kdr mutations, metabolic detoxification, and behavioral adaptations, significantly compromising chemical control strategies. Additionally, semiochemicals, including aldehydes, aggregation pheromones, and host-derived essential oils, aggregation, and host localization, represent promising targets for monitoring and integrated pest management. Control approaches that combine heat treatment, physical exclusion, environmental sanitation, and selective use of effective insecticides show the highest efficacy, particularly in settings with recurrent or high-density infestations. Understanding the biological and chemical ecology of these species is crucial for improving detection tools, surveillance programs, and long-term management strategies. The evidence presented reinforces the need for integrated interventions supported by continuous research to mitigate the growing impact of bed bugs on public health worldwide.

Abbreviations

VOC: Volatile Organic Compound; VOCs: Volatile Organic Compounds; IPM: Integrated Pest Management; spp: Species; CO_2: Carbon Dioxide; KDR: Widespread.

Introduction

Bed bugs (Hemiptera: Cimicidae) have re-emerged as significant public health pests, affecting households, shelters, public institutions, and transportation systems worldwide. Infestations caused by C. hemipterus and C. lectularius have increased globally over the past two decades, driven by urbanization, human mobility, and the development of insecticide resistance [1-5].

Although bed bugs are not recognized as vectors of infectious diseases, their bites may induce pruritic wheals, bullous eruptions, and hypersensitivity reactions, in addition to precipitating insomnia, anxiety, and reduced quality of life. Their ability to withstand long periods of starvation, hide in narrow crevices, and survive across a broad temperature range enhances their persistence in human environments. This ecological and physiological resilience has contributed

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Available from: https://dx.doi.org/10.17352/ei.000003

substantially to their re-establishment in regions where they had nearly disappeared in the late 20th century [6-10].

Infestations have become increasingly common in residential buildings, shelters, dormitories, and transportation systems worldwide. The pest control practices, urbanization, and the widespread use of insecticides. Reports of infestations in healthcare facilities and the hospitality industry reflect the capacity of bed bugs to disperse passively through human belongings and secondhand materials [11-15].

Two major species are associated with human infestations: C. lectularius, which predominates in regions, and C. hemipterus, which is more common in tropical and subtropical climates. Although these species share similar morphology and behavior, they differ in ecological preferences, thermal tolerance, developmental rates, and degrees of insecticide resistance. Understanding these distinctions is essential for accurate diagnosis, epidemiological surveillance, and the implementation of effective control strategies [16-19].

Recent advances in molecular techniques, chemical ecology, and population genetics have expanded current understanding of the biology and dispersal patterns of Cimex Linnaeus, 1758. These tools have clarified infestation sources, movement within multi-unit housing, and the spread of insecticide-resistance alleles. Integrating these approaches has enhanced surveillance capacity and supported the development of improved control programs worldwide [20-25].

The biological success of C. lectularius and C. hemipterus is partly attributed to their cryptic habits, rapid hiding responses, nocturnal feeding behavior, and high thermal tolerance, allowing survival in a wide variety of human dwellings. Their ability to survive months without feeding and reproduce efficiently under favorable temperatures makes infestations persist even when environmental interventions temporarily reduce population density. These traits, combined with increased resistance to pyrethroids, neonicotinoids, and other insecticide classes, have complicated traditional eradication strategies used in previous decades [20-23].

In addition to their biological characteristics, bed bugs exert a significant psychological and economic burden on affected individuals and communities. Reports of anxiety, insomnia, social embarrassment, and financial losses are common in households, hotels, dormitories, and public institutions. Infestations often require extensive structural cleaning, heating treatments, insecticide applications, and specialized inspections, representing a substantial logistical challenge. The combination of dermatological symptoms, allergic reactions, and emotional stress underscores the need for updated research-based approaches to pest management [24-27].

The objective of this review is to synthesize current global knowledge on the biology, ecology, public health relevance, and control strategies of two species. The study aims to compare the two species in terms of morphology, geographic distribution, behavior, insecticide resistance, and clinical effects on humans. Additionally, this review evaluates recent advances in chemical ecology, detection methods, and integrated pest management (IPM), providing an updated framework to support surveillance programs and evidence-based control strategies worldwide [28-31].

Methods

This integrative review was conducted between 2000 and 2025 and followed established guidelines for narrative scientific reviews. A comprehensive search of the literature was conducted on the internet. The search strategy included the following terms in various combinations: C. lectularius, C. hemipterus, bed bugs, insecticide resistance, biology, ecology, chemical ecology, VOCs, pheromones, public health, and integrated pest management.

Articles were included if they reported biological, ecological, epidemiological, clinical, molecular, or control-related data on C. lectularius or C. hemipterus. Original research articles, reviews, epidemiological reports, books, government documents, and clinical case reports were considered. Publications without methodological clarity, duplicated data, or unrelated to the research themes were excluded.

All selected studies were evaluated based on relevance, scientific quality, and contribution to the understanding of the species. Data were extracted and synthesized into thematic axes, including morphology, geographic distribution, life cycle, clinical effects, chemical ecology, insecticide resistance, and control strategies. Descriptive analysis was employed, as meta-analytic procedures were not applicable due to methodological variability among the studies.

Results

One hundred and twelve (112) publications were used to prepare the manuscript. The studies covered biological, ecological, clinical, molecular, and control-related aspects of the two species of Cimex Linnaeus, 1758between 2000/2025. The findings were organized into major thematic categories to facilitate interpretation.

Cimex hemipterus exhibits a flattened, oval body structure, adapted for cryptic life within furniture crevices, mattress seams, and structural fissures, allowing for rapid concealment after feeding. Bed bugs displayed coloration ranging from light brown to dark reddish-brown depending on feeding status, and the hemelytra remnants were visibly reduced, indicating evolutionary specialization for a wingless parasitic lifestyle. The presence of elongated stylets forming a functional proboscis allowed efficient piercing of the host's skin, and their dorsoventrally flattened shape facilitated the occupation of extremely narrow hiding places, a feature that contributes substantially to infestation persistence in various environments. Life cycle of C. lectularius (Figure 1) [32-34].

Comparative morphological analyses revealed consistent differences between C. lectularius and C. hemipterus, including pronotum shape, antennal segment proportions, dorsal setae distribution, and thermal tolerance. These diagnostic traits were essential for species identification in field investigations

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and matched the descriptions provided in classical taxonomy. Both species showed morphological adaptations associated with hematophagy and nocturnal feeding (Figure 2).

Behavioral observations confirmed that mating frequency was high under warm and stable environmental conditions, with copulatory attempts occurring even in suboptimal nutritional states. These reproductive traits, combined with egg-laying behavior concentrated in protected areas, enhance population establishment in urban settings where continuous host availability enables uninterrupted reproductive cycles (Figures 3,4) [35-37].

Nymphal resilience was notable, as individuals tolerated prolonged intervals between feedings and maintained mobility even under low humidity conditions. The life cycle duration varied between 35 and 60 days depending on temperature, and population expansion occurred rapidly in heated buildings. Observations from infested environments demonstrated clustering behavior, with aggregations forming under mattresses, inside bed frames, and along curtain folds, a behavior influenced by aggregation pheromones emitted by nymphs and adults [38-40].

Feeding behavior studies indicated that bed bugs generally consumed blood for 5 to 10 minutes and returned to their shelters before the host detected irritation. Dermatological reactions varied widely, including papules, erythema, vesicles, and bullous hypersensitivity. Although no conclusive evidence supported pathogen transmission, anemia, psychological distress, and sleep disruption were recurrently documented, particularly in chronic infestations (Figure 5).

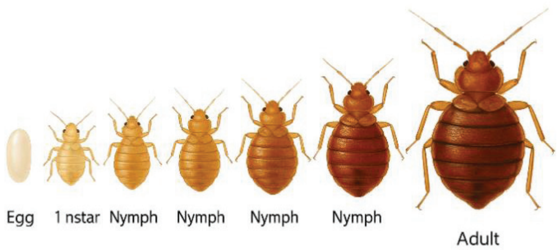

Figure 1: Life cycle of *C. lectularius*, schematic representation of the bed bug life cycle, illustrating egg, five nymphal instars, and adult stages. The diagram highlights the progressive morphological changes during development and emphasizes temperature-dependent variation in developmental duration.

Figure 2: Dorsal morphology of *C. lectularius*, showing the head, thorax, and abdomen with well-defined segmentation, antennae, and six legs. The illustration highlights the flattened oval body typical of the species and the cuticular texture that facilitates concealment in narrow crevices. This arrangement reflects the structural adaptations that support mobility, feeding, and survival in human dwellings.

Figure 3: Diagnostic anatomical structures of *C. lectularius*. Detailed illustrations of (A) mouthparts, including proboscis and stylets; (B) ventral view with legs and abdominal sternites; and (C) head anatomy showing antennae and compound eyes. These elements support species-level differentiation.

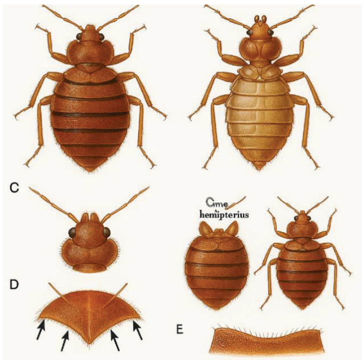

Figure 4: Morphological characterization of *C. lectularius*, showing dorsal and ventral views, a detailed head illustration, diagnostic setae distribution, and a comparative representation with *C. lectularius*. These visual features highlight taxonomic traits used for accurate differentiation between tropical and common bed bug species. The figure emphasizes structural variations essential for entomological identification and field surveillance.

Figure 5: High-resolution macro image of *C. lectularius*, actively feeding on human skin. The photograph highlights the proboscis inserted into the dermis, abdominal expansion during hematophagy, and the change in coloration as the midgut fills with blood. This visual representation illustrates the characteristic feeding behavior of bed bugs, including rapid engorgement and their ability to remain undetected due to salivary anesthetics and anticoagulants. The image provides practical diagnostic value for clinical and entomological identification of active infestations.

Immunological responses in humans varied, with some individuals developing papular urticaria, bullous lesions, or delayed hypersensitivity reactions. Field observations confirmed that psychological disturbances, including insomnia and anxiety, were common among affected individuals. The silent and nocturnal feeding strategy, combined with painless biting due to salivary anesthetics and anticoagulants, contributed to diagnostic difficulty, especially in homes without visible infestation signs [41-43].

The environmental distribution assessment showed that C. hemipterus dominated tropical and subtropical regions, while

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C. Lectularius predominated in temperate climates; however, overlap zones were identified in cosmopolitan settings with high mobility (Figure 6).

Infestations were frequently reported in hotels, dormitories, hospitals, and public transport. Increased international travel played an important role in redistributing populations, as bed bugs readily dispersed through luggage and secondhand furniture. The species demonstrated a preference for temperatures between 25°C and 30°C, and climate-controlled buildings enabled survival even in colder regions, partially explaining the expanding range of C. hemipterus [44-46].

Chemical control evaluation revealed extensive resistance to pyrethroids, neonicotinoids, and carbamates, with genetic analyses indicating kdr-type mutations in sodium channel genes. Heat treatment above 45°C for 90 minutes remained effective in eliminating eggs, nymphs, and adults, and was identified as one of the most reliable methods for large infestations. Vacuuming, steaming, and sealing structural crevices demonstrated synergistic efficiency when combined with chemical products. Behavioral resistance, including avoidance of treated surfaces, was also noted and contributed to control challenges [47–48].

In addition to primary species, secondary cimicid species were recorded in specific environments, including Cimex pilosellus (Horváth, 1910), associated with bats, Oeciacus vicarius Horváth, 1912, associated with swallows, and Haematosiphon inodorus (Dugès, 1892), associated with poultry (Figure 7).

Although these species occasionally bit humans, they rarely sustained populations without their natural hosts. Morphological examinations revealed adaptations in their claws, mouthparts, and setal patterns consistent with their preferred hosts. These findings highlight the importance of accurate taxonomic identification in suspected infestations near wildlife habitats [49].

Chemical ecology analysis demonstrated that VOCs emitted by bed bugs played essential roles in aggregation, mating, defense, and host seeking (Figure 8).

Compounds such as nonanal, decanal, and several aldehydes acted as aggregation signals, facilitating group formation. The use of VOC-based detection tools has grown as an alternative to canine inspection, with potential for early identification of low-density infestations. These chemical signals also offer potential for the development of new lures and traps in integrated management programs (Figures 9,10) [50].

Recent field reports confirmed the presence of C. lectularius in new geographic areas, including Southern Brazil, where infestations were documented in densely populated residential units and public shelters (Figure 10).

European cities preceding the 2024 Olympic Games. Epidemiological trends indicated a resurgence beginning in the early 1990s, driven by insecticide resistance, increased travel, and reduced use of residual insecticides in domestic environments. These results underscore the need for

Figure 6: Global distribution of *C. lectularius*. Map showing confirmed occurrences of the species across temperate and subtropical regions, including North America, Europe, Africa, Asia, and Oceania. The distribution illustrates worldwide expansion associated with human mobility and urbanization. This pattern reflects the widespread adaptability of bed bugs to diverse environmental and socioeconomic conditions.

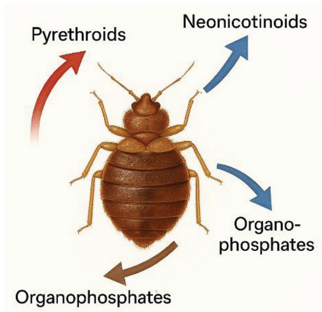

Figure 7: Schematic representation of insecticide resistance in *C. lectularius*, illustrating the association of the species with reduced susceptibility to multiple chemical classes commonly used in urban pest control. The figure emphasizes the role of metabolic detoxification and target-site mutations in decreasing the efficacy of conventional treatments. This pattern of resistance highlights the need for integrated management strategies and rotation of active ingredients.

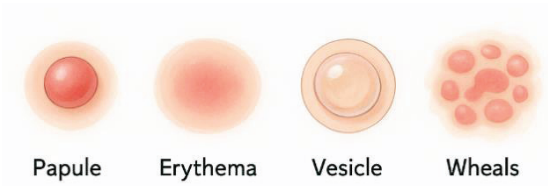

Figure 8: Illustrated representation of common cutaneous reactions associated with bed bug bites, including papules, erythema, vesicles, and wheals. The diagram highlights the variation in inflammatory patterns that may occur depending on individual sensitivity and immune response. These stylized lesions provide a clear visual summary of dermatological manifestations frequently reported in infestations.

standardized surveillance systems capable of monitoring infestation dynamics at regional and national levels [48-50].

The morphological and ecological differences between the two hemipterans make accurate species identification essential in infested environments [1,3,14]. Populations show variations in geographic distribution, body size, environmental preferences, and levels of insecticide resistance, all of which directly influence infestation dynamics [22,38,49].

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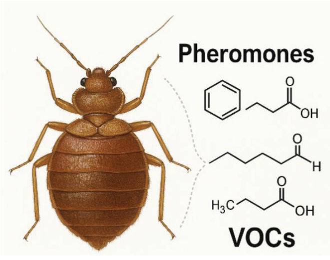

Figure 9: Illustrated representation of semiochemicals associated with *C. lectularius*, including pheromones and volatile organic compounds involved in aggregation, communication, and host-related chemical signaling. The diagram highlights key molecules released by bed bugs that influence behavior and detection. These compounds play a central role in environmental monitoring and the development of attractant-based control strategies.

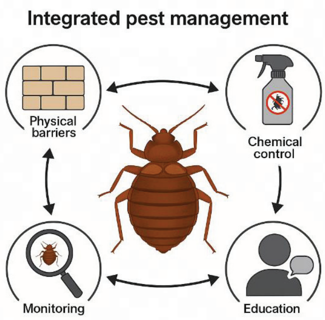

Figure 10: Schematic representation of Integrated Pest Management (IPM) strategies for bed bugs, illustrating the combined use of physical barriers, chemical interventions, education, and continuous monitoring. The figure highlights the complementary nature of these approaches in preventing reinfestation and improving long-term control outcomes. This integrated framework reinforces the importance of coordinated actions for effective bed bug management. Increased media attention and public concern paralleled the spread of infestations in major cities.

Comparing these characteristics supports the development of appropriate management strategies for both temperate and tropical regions. The analysis further demonstrates that both species hold significant medical and sanitary importance due to their high adaptability to human environments (Table 1) [5,30,46].

The biological cycle of bed bugs demonstrates substantial ecological plasticity and tolerance to adverse environmental conditions [3,25,33]. Differences in the duration of each nymphal instar and the overall life cycle depend on temperature, host availability, and species-specific traits [10,25,41]. Comparing developmental stages helps explain how infestations can expand rapidly, particularly in tropical regions where C. hemipterus often develops faster [36,42]. These insights are essential for guiding surveillance and control measures based on population dynamics observed under field conditions. Biological cycle and duration of developmental stages (Table 2) [38,49].

The effectiveness of bed bug control strategies varies widely according to infestation level, insecticide resistance, and environmental characteristics [2,11,22]. Integrated pest management (IPM) approaches provide superior outcomes by combining physical, chemical, and behavioral interventions, which help reduce selective pressure and delay resistance development [16,19,41]. Comparative analyses show that heat treatment remains highly effective, whereas chemical control has diminished performance due to metabolic resistance and target-site mutations [20,28,47]. These findings are essential for developing sustainable, region-specific control practices.

Table 3 evaluates the comparison of bed bug control methods and their effectiveness and relative efficiency [50]. High levels of resistance to pyrethroids, neonicotinoids, and carbamates were consistently reported. Molecular studies

Table 1: Comparative characteristics of *Cimex hemipterus* (Fabricius, 1803) and *Cimex lectularius* (Linnaeus, 1758), highlighting key morphological and ecological differences between the two species. The table summarizes diagnostic traits, developmental patterns, and behavioral aspects essential for species identification. These distinctions support accurate classification and guide control strategies in distinct climatic regions.

Characteristic	*C. lectularius*	*C. hemipterus*
Primary distribution	Temperate regions	Tropical and subtropical regions
Dorsal morphology	Pronotum less expanded; margins smoother	Pronotum more expanded; margins more serrated
Antennae	Shorter segments; subtle differentiation	Longer segments; segment II proportionally longer
Body size (adult)	4–6 mm	5–7 mm
Thermal tolerance	Moderate; prefers 18–28°C	Higher tolerance; thrives at 25–32°C
Insecticide resistance	Increasing	Very high and widespread
Preferred habitat	Residential buildings; hotels	High-density dwellings; hostels; warm environments
Clinical reactions in humans	Papules, erythema, pruritus	Same reactions, often more intense in warm climates
Feeding behavior	Nocturnal; 5–10 min feeding	Nocturnal; similar feeding duration
Eggs and nymph development	Moderate developmental rate	Faster development at high temperatures
Public health relevance	High	Very high in tropical countries

Table 2: Volatile Organic Compounds (VOCs) and pheromones identified in *Cimex* sp., highlighting aldehydes and key semiochemicals involved in communication and defense. These compounds mediate aggregation, alarm responses, and host-seeking behavior. Understanding their roles supports the development of detection tools and attractant-based control strategies.

Compound	Chemical class	Detected in	Biological function
(E)-2-Hexenal	Aldehyde	*C. lectularius* and *C. hemipterus*	Defense secretion; alarm signal
(E)-2-Octenal	Aldehyde	*Cimex* spp.	Aggregation and alarm pheromone
Nonanal	Aldehyde	*C. lectularius*	Aggregation cue
Decanal	Aldehyde	*C. lectularius*	Aggregation; communication
4-Oxo-(E)-2-hexenal	Aldehyde derivative	*Cimex* spp.	Key defensive volatile
4-Oxo-(E)-2-octenal	Aldehyde derivative	*Cimex* spp.	Alarm response mediator
Butyric acid	Carboxylic acid	*C. lectularius*	Weak attractant; host mimic
Lactic acid	Organic acid	Environmental	Host cue
CO_2	Inorganic volatile	Environmental	Host-seeking trigger
Human skin VOC blends	Mixed	Environmental	Attractant synergy

spp: Species

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Table 3: Summarizes how infestation level, insecticide resistance, and environmental conditions influence treatment performance. Integrated pest management (IPM) consistently provides the most reliable outcomes by combining chemical, physical, and behavioral strategies that reduce selective pressure and delay resistance.

Control Method	Description	Effectiveness	Limitations
Heat treatment	Exposure of all life stages to >45 °C	Very high	Requires professional equipment; cost
Chemical insecticides	Pyrethroids, neonicotinoids, desiccants	Moderate to low	Resistance increasingly common
Steam application	Direct high-temperature application to surfaces	High	Limited penetration; operator-dependent
Vacuuming	Removal of bugs and eggs from harborages	Moderate	Does not eliminate hidden individuals
Mattress encasements	Physical isolation of harborages	Moderate	Requires long-term maintenance
Monitoring traps	CO_2 or interceptor-based detection tools	Variable	Less effective in low-density infestations
Integrated Pest Management (IPM)	The combination of physical, chemical, and behavioral strategies	High (most reliable)	Requires coordinated, continuous implementation

IPM: Integrated Pest Management; CO_2: Carbon dioxide.

identified Widespread (KDR) mutations and metabolic detoxification pathways. Resistance was more intense in C. hemipterus, especially in tropical regions, reinforcing the need for rotation of active ingredients and integrated management approaches [19,41].

Conclusion

Bed bugs remain resilient urban pests with significant public health and socioeconomic impact. Their biological adaptability, capacity to survive long periods without feeding, and growing insecticide resistance have contributed to their worldwide resurgence. Although not confirmed vectors of infectious diseases, C. lectularius and C. hemipterus cause considerable dermatological and psychological distress. Effective management requires integrated approaches combining chemical, physical, and environmental strategies, as well as improved detection technologies. Continued research and surveillance are essential to reduce the global burden associated with these hematophagous insects [32-50].

Acknowledgments

The authors acknowledge the support of entomological research institutions, vector surveillance units, and academic databases that contributed to the literature used in this review. We also thank the professionals involved in pest management, clinical investigations, and epidemiological studies for advancing knowledge of C. lectularius and C. hemipterus. This work is dedicated to researchers seeking innovative and safe control strategies for bed bug infestations.

References

1. Doggett SL, Dwyer DE, Peñas PF, Russell RC. Bed bugs: clinical relevance and control options. Clin Microbiol Rev. 2012;25(1):164–192. Available https://doi.org/10.1128/cmr.05015-11
2. Romero A, Potter MF, Potter DA, Haynes KF. Insecticide resistance in the bed bug: a factor in the pest's sudden resurgence? J Med Entomol. 2007;44(2):175–178. Available from: https://doi.org/10.1603/0022-2585(2007)44[175:iritbb]2.0.co;2
3. Reinhardt K, Siva-Jothy MT. Biology of the bed bugs (Cimicidae). Annu Rev Entomol. 2007;52:351–374. Available from: https://doi.org/10.1146/annurev.ento.52.040306.133913
4. Parola P, Izri A. Bedbugs. N Engl J Med. 2020;382(23):2230–2237. Available from: https://doi.org/10.1056/nejmcp1905840
5. Goddard J, deShazo R. Bed bugs and clinical consequences of their bites. JAMA. 2009;301(13):1358–1366. Available from: https://doi.org/10.1001/jama.2009.405
6. Hwang SW, Svoboda TJ, De Jong IJ, Kabasele KJ, Gogosis E. Bed bug infestations in an urban environment. Emerg Infect Dis. 2005;11(4):533–538. Available from: https://doi.org/10.3201/eid1104.041126
7. Leverkus M, Jochim RC, Schäd S, Bröcker EB, Andersen JF, Valenzuela JG, et al. Bullous allergic hypersensitivity to bed bug bites. J Invest Dermatol. 2006;126(1):91–96. Available from: https://doi.org/10.1038/sj.jid.5700012
8. Campbell BE, Miller DM. Insecticide resistance in eggs and first instars of the bed bug. Insects. 2015;6(1):122–132. Available from: https://doi.org/10.3390/insects6010122
9. Weeks ENI, Birkett MA, Cameron MM, Pickett JA, Logan JG. Semiochemicals of Cimex lectularius. Pest Manag Sci. 2011;67(1):10–20. Available from: https://doi.org/10.1002/ps.2024
10. Dang K, Doggett SL, Singham GV, Lee CY. Insecticide resistance mechanisms in Cimex spp. Parasit Vectors. 2017;10:318. Available from: https://doi.org/10.1186/s13071-017-2232-3
11. Lai O, Ho D, Glick S, Jagdeo J. Bed bugs and possible transmission of human pathogens. Arch Dermatol Res. 2016;308(8):531–538. Available from: https://doi.org/10.1007/s00403-016-1661-8
12. Sheele JM, Pritt BS, Libertin CR, . Bed bugs are associated with anemia. Am J Emerg Med. 2021;46:482–488. Available from: https://doi.org/10.1016/j.ajem.2020.10.070
13. Pritchard MJ, Hwang SW. Severe anemia from bedbugs. CMAJ. 2009;181(5):287–288. Available from: https://doi.org/10.1503/cmaj.090482
14. Akhoundi M, Zumelzu C, Sereno D, Marteau A, Brun S, Jan J, et al. Bed bugs: a global challenge. Diagnostics. 2023;13(14):2281. Available from: https://doi.org/10.3390/diagnostics13132281
15. Ashcroft R, Seko Y, Chan LF, Dere J, Kim J, McKenzie K. Mental health impact of bed bug infestations. Int J Public Health. 2015;60(7):827–837. Available from: https://doi.org/10.1007/s00038-015-0713-8
16. Doggett SL, Miller DM, Lee CY, editors. Advances in the biology and management of modern bed bugs. Wiley-Blackwell; 2018.
17. Boase CJ. Bedbugs – back from the brink. Pestic Outlook. 2001;12(4):159–162. Available from: https://pubs.rsc.org/en/content/articlelanding/2001/po/b106301b
18. World Health Organization (WHO). Global status report on non-communicable diseases. 2014. Available from: https://www.who.int/publications/i/item/9789241564854
19. Adelman ZN, Kilcullen KA, Koganemaru R, Anderson MAE, Anderson TD, Miller DM. Anderson,Troy D. Anderson,Dini M. Miller. Deep sequencing of

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Available from: https://dx.doi.org/10.17352/ei.000003

pyrethroid-resistant bed bugs. PLoS One. 2011;6(10):e26228. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0026228

20. Zhu F. Knockdown resistance mutations in Cimex lectularius. Arch Insect Biochem Physiol. 2010;73(4):245–257.

21. Koganemaru R, Miller DM. The bed bug problem. Pestic Biochem Physiol. 2013;106(3):177–189. Available from: https://doi.org/10.1016/j.pestbp.2013.05.005

22. Romero A, Potter MF, Haynes KF. Chlorfenapyr evaluation. J Econ Entomol. 2010;103(4):1365–1375.

23. How YF, Lee CY. Sublethal exposure and reproductive fitness. J Econ Entomol. 2011;104(3):986–992.

24. Balvin O. Coexistence of Cimex species. Med Vet Entomol. 2015;29(1):110–116.

25. Booth W, Saenz VL, Santangelo RG, Wang C, Schal C, Vargo EL. Infestation dynamics in apartment buildings. J Med Entomol. 2012;49(3):535–546. Available from: https://doi.org/10.1603/ME11256

26. Potter MF, Haynes KF, Fredericks J. Bed bugs across America. PestWorld. 2015.

27. Raab RW. Bartonella DNA in bed bugs. Emerg Infect Dis. 2022;28(4):812–817.

28. Akhoundi M, Sereno D, Durand R, Mirzaei A, Bruel C, Delaunay P, et al. A. Bed Bugs (Hemiptera, Cimicidae): Overview of Classification, Evolution and Dispersion. Int J Environ Res Public Health. 2020; 25;17(12):4576. Available from https://doi.org/10.3390/ijerph17124576

29. Barbarin AM, Jenkins NE, Rajotte EG, Thomas MB. Entomopathogenic fungi for bed bug control. J Invertebr Pathol. 2012;111(1):82–85.

30. Singh N, Wang C, Cooper R. Feeding behavior of Cimex lectularius. Insects. 2013;4(4):551–562.

31. Wang C. Dispersal in apartment buildings. J Econ Entomol. 2010;103(1):172–177.

32. Cooper R, Wang C, Singh N. High movement of bed bugs. PLoS One. 2015;10(9):e0136462.

33. Aak A, Rukke BA. Blood sources and life history parameters. Med Vet Entomol. 2014;28(1):60–70.

34. Jones SC. Behavioral responses to insecticides. J Econ Entomol. 2013;106(6):2424–2431.

35. Singh N, Wang C. Essential-oil-based pesticide evaluation. J Econ Entomol. 2016;109(6):2724–2730.

36. Wang C. Heat and residual insecticides. Pest Manag Sci. 2016;72(4):660–665.

37. Barbarin AM, Bellicanta GS, Gibbs AG. Lower thermal limits. J Med Entomol. 2012;49(6):1352–1355.

38. Polanco AM, Brewster CC, Miller DM. Survivorship during starvation. Insects. 2011;2(2):232–242. Available from: https://doi.org/10.3390/insects2020232

39. DeVries ZC, Kells SA, Appel AG. Metabolic rate and temperature. J Med Entomol. 2013;50(5):947–954.

40. Cooper R, Schal C. Blood feeding behavior. J Med Entomol. 2021;58(3):1320–1328.

41. Feldlaufer MF, Domingue MJ, Chauhan KR. Aggregation pheromone. J Med Entomol. 2010;47(4):567–574.

42. Benoit JB, et al. Heat shock proteins. Am J Trop Med Hyg. 2009;80(4):667–672.

43. Harraca V, et al. Olfactory orientation. J Exp Biol. 2010;213(18):3470–3477.

44. Benoit JB, Adelman ZN, Reinhardt K, Dolan AC, Poelchau MF. Bed bug genomics. Annu Rev Entomol. 2016;61:393–411.

45. Singha D, Singh S. Cimicidae systematics. Syst Entomol. 2020;45(3):556–572.

46. Weeks ENI. Pheromone component in feces. J Chem Ecol. 2013;39(4):483–493.

47. Iwanaga K, Kakiuchi M. Control in high-density housing. Trop Med Health. 2021;49:42.

48. Wang C, Cooper R. Environmentally safe control. J Integr Pest Manag. 2011;2(2):1–6.

49. Schnepp K, Gareth Powell G. A New Species of Sandalus Knoch (Coleoptera: Rhipiceridae), with an Updated Key to the Species of the Eastern USA. Coleopt Bull. 2018;72(2):241-245. Available from https://doi.org/10.1649/0010-065X-72.2.241

50. The Guardian. Bed bug resurgence in Europe raises public health alerts. The Guardian. 2024.

Citation: Vinícios de Oliveira Santana M, Marchiori CH, Paula Malheiros KD, de Melo ÈM. Bed Bugs and Human Health: A Global Review of *Cimex hemipterus* (Fabricius, 1803) and *Cimex lectularius* (Linnaeus, 1758) (Hemiptera: Cimicidae). Entomol Insights. 2025; 2(1): 001-007. Available from: https://dx.doi.org/10.17352/ei.000003