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ENVIRONMENTALLY FRIENDLY ALTERNATIVES FOR URBAN PEST CONTROL AND INSECTICIDE RESISTANCE MANAGEMENT

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Abstract Urban pests have become increasingly challenging to manage in this era due to high levels of insecticide resistance and the decreased availability of sustainable products. Easily accessible DIY insecticides also contribute to the buildup of insecticide resistance due to their low efficacy and the increased selection pressure they create. There is significant public demand for low-risk insecticides and other sustainable alternative technologies. This presentation will highlight environmentally friendly alternatives and explore the future potential for their use in urban pest control and resistance management.

Keywords insecticide resistance, botanicals, biologicals, alternatives

INTRODUCTION

The pest control industry heavily relies on insecticides for urban pest management. However, persistent and prolonged use of these chemicals has caused several species to develop high levels of resistance to multiple classes of insecticides (Lee et al., 2018; Gondhalekar and Scharf, 2021). In particular, bed bugs and German cockroaches have presented significant challenges due to widespread reports of insecticide resistance globally (Romero, 2018; Scharf and Gondhalekar, 2021). Additionally, residents often use various DIY insecticide products, which have worsened resistance issues (Gordon et al., 2024).

Multiple mechanisms are involved in insecticide resistance such as target site insensitivity, elevated enzyme activity, cuticle thickening, and behavioral resistance (Romero, 2018; Scharf and Gondhalekar, 2021). To address and manage insecticide resistance in cockroaches and bed bugs, integrated pest management (IPM) strategies are recommended. These include physical or non-chemical control measures, environmentally friendly botanical chemicals and desiccants, the use of synergists, and insecticide rotation with different modes of action. Below are some of the commonly used and proven environmentally friendly alternatives for bed bug and cockroach control.

DISCUSSION

Plant essential oils and their derived compounds have demonstrated promising results against bed bugs and cockroaches in laboratory experiments. Gaire et al. (2019, 2020) showed that both essential oils and their derived compounds can kill susceptible and pyrethroid-resistant bed bugs. Furthermore, Gaire et al. (2021) found that essential oils can restore pyrethroid toxicity by inhibiting cytochrome P450 enzymes in highly resistant bed bugs. However, despite the known toxicities of essential oils, only a few market products have proven effective against bed bugs (Singh et al., 2014), indicating the need for robust research and development.

Essential oils have also been shown to be toxic to various cockroach species, including Turkestan and German cockroaches (Phillips et al., 2010; Gaire et al., 2017). Additionally, certain essential oils exhibit repellency against both bed bugs and cockroaches (Gonzalez-Morales et al., 2021; Gaire et al., 2017; Appel et al., 2001).

Heat treatments are a widely used control method for bed bugs globally (Kells, 2018). Bed bugs are highly susceptible to heat, whether through whole-home heating, localized compartment heating, or steam treatments. However, high heat treatments can negatively affect buildings and household items (Kells, 2018; Puckett et al., 2013; Wang et al., 2018). Freezing temperatures can also kill bed bugs, but their efficacy has been inconsistent in existing products (Kells, 2018). While both heat and cold can kill cockroaches, their use has not been as extensively studied or implemented compared to bed bug treatments (Gondhalekar et al., 2021).

Gaseous treatments, such as carbon dioxide (CO2), ozone, and ultra-low oxygen, have shown effectiveness against bed bugs in small compartments (Wang et al., 2012; Feston et al., 2012; Liu and Haynes, 2016). However, their large-scale application remains challenging due to side effects, and similar limitations apply to their use for cockroach control.

Desiccant dusts containing agents such as silica and diatomaceous earth are popular for bed bug and cockroach control. These products degrade the insect cuticle and accelerate water loss (Singh et al., 2016; Scharf and Gondhalekar, 2021). Mechanical or physical control methods, such as vacuuming, trapping, and physical removal, are also effective for managing bed bugs and cockroaches (Wang and Bennett, 2006; Wang et al., 2011). Traps are particularly useful for monitoring and removing pests, as well as reducing allergens from pest feces and exuviae (Gondhalekar et al., 2021; Kells, 2018).

Emerging concepts, such as microbiome and genetic approaches, have been studied extensively in recent decades for controlling various urban pests including bed bugs and cockroaches (Doggett et al., 2018; Wang et al., 2021). Entomopathogenic fungi have shown efficacy against these pests (Barbarin et al., 2012; Ulrich et al., 2014; Zhang et al., 2021). For example, a product based on *Beauveria bassiana* has gained popularity for bed bug control, although its large-scale implementation faces challenges related to precise use, handling, and cost.

RNA interference (RNAi) methods have also been employed to knock down genes associated with resistance development in bed bugs and cockroaches (Romero, 2018; Scharf and Gondhalekar, 2021). However, no products based on RNAi are commercially available yet, and regulatory policies for indoor use remain unclear (Doggett et al., 2018; Scharf and Gondhalekar, 2021; Gondhalekar et al., 2021).

In conclusion, several studies have demonstrated the effectiveness of alternative control methods for both susceptible and resistant bed bugs and German cockroaches. Incorporating these methods into IPM strategies can help reduce the overuse of synthetic pesticides, ultimately mitigating urban pest pressures and insecticide resistance issues.

REFERENCE CITED

Appel, A.G., M.J. Gehret and M.J., Tanley. 2001. Repellency and toxicity of mint oil to American and German cockroaches (Dictyoptera: Blattidae and Blattellidae). J. Agric. Urban Entomol, 18(3): 149-156.

Barbarin, A.M., N.E. Jenkins, E.G. Rajotte and M.B. Thomas. 2012. A preliminary evaluation of the potential of Beauveria bassiana for bed bug control. J. Invertebr. Pathol. 111(1): 82-85.

Doggett, S.L., D.M. Miller and C.Y. Lee. eds., 2018. Advances in the biology and management of modern bed bugs. John Wiley & Sons.

Feston, J., S. Gaire, M. Fardisi, L.J. Mason and A.D. Gondhalekar. 2020. Determining baseline toxicity of ozone against an insecticide-susceptible strain of the common bed bug, *Cimex lectularius* L. under laboratory conditions. Pest Manag. Sci. 76(9): 3108-3116.

Gaire, S., C.D. Lewis, W. Booth, M.E. Scharf, W. Zheng, M.D. Ginzel and A.D. Gondhalekar. 2020. Bed bugs, Cimex lectularius L., exhibiting metabolic and target site deltamethrin resistance are susceptible to plant essential oils. Pestic. Biochem. Phys.169: 104667.

Gaire, S., M. O'Connell, F.O. Holguin, A. Amatya, S. Bundy and A. Romero 2017. Insecticidal properties of essential oils and some of their constituents on the Turkestan cockroach (Blattodea: Blattidae). J. Econ. Entomol. 110(2): 584-592.

Gaire, S., M.E. Scharf and A.D. Gondhalekar. 2019. Toxicity and neurophysiological impacts of plant essential oil components on bed bugs (Cimicidae: Hemiptera). Sci. Rep. 9(1): 3961.

Gondhalekar, A.D., A.G. Appel, G.M. Thomas and A. Romero. 2021. A review of alternative management tactics employed for the control of various cockroach species (Order: Blattodea) in the USA. Insects, 12(6): 550.

González-Morales, M.A., M. Terán and A. Romero. 2021. Behavioral responses of the common bed bug to essential oil constituents. Insects. 12(2): 184.

Gordon, J.M., M.J. Eva, S. Gaire, A.G. Appel and Z.C. DeVries. 2024. Common consumer residual insecticides lack efficacy against insecticide-susceptible and resistant populations of the German cockroach (Blattodea: Ectobiidae). J. Econ. Entomol. 117(5): 2051-2059.

Kells, S.A. 2018. Non-chemical control. Advances in the biology and management of modern bed bugs, pp.257-272.

Lee, C.Y., D.M. Miller and S.L. Doggett. 2018. Chemical control. Advances in the biology and management of modern bed bugs, pp.285-310.

Liu, Y.B. and K.F. Haynes. 2016. Effects of ultralow oxygen and vacuum treatments on bed bug (Heteroptera: Cimicidae) survival. J. Econ. Entomol. 109(3): 1310-1316.

Phillips, A.K., A.G. Appel and S.R. Sims. 2010. Topical toxicity of essential oils to the German cockroach (Dictyoptera: Blattellidae). J. Econ. Entomol.103(2): 448-459.

Puckett, R.T., D.L. McDonald and R.E. Gold. 2013. Comparison of multiple steam treatment durations for control of bed bugs (Cimex lectularius L.). Pest Manag. Sci. 69(9): 1061-1065.

Romero, A. 2018. Insecticide resistance. Advances in the biology and management of modern bed bugs, pp.273-284.

Scharf, M.E. and A.D. Gondhalekar. 2021. Insecticide resistance: perspectives on evolution, monitoring, mechanisms and management. Biology and Management of the German cockroach. pp. 231-255. Boston (MA): CABI.

Singh, N., C. Wang and R. Cooper. 2014. Potential of essential oil-based pesticides and detergents for bed bug control. J. Econ. Entomol. 107(6): 2163-2170.

Singh, N., C. Wang, D. Wang, R. Cooper and C. Zha. 2016. Comparative efficacy of selected dust insecticides for controlling Cimex lectularius (Hemiptera: Cimicidae). J. Econ. Entomol. 109(4): 1819-1826.

Ulrich, K.R., M.F. Feldlaufer, M. Kramer and R.J. St. Leger. 2014. Exposure of bed bugs to Metarhizium anisopliae at different humidities. J. Econ. Entomol. 107(6): 2190-2195.

Wang, C. and G.W. Bennett. 2006. Comparison of cockroach traps and attractants for monitoring German cockroaches (Dictyoptera: Blattellidae). Environ. Entomol. 35(3): 765-770.

Wang, C., C.Y. Lee and M.K. Rust. 2021. Biology and management of the German cockroach. CSIRO PUBLISHING.

Wang, C., L. Lü and M. Xu. 2014. Carbon dioxide fumigation for controlling bed bugs. J. Med. Entomol. 49(5): 1076-1083.

Wang, C., W.T. Tsai, R. Cooper and J. White. 2011. Effectiveness of bed bug monitors for detecting and trapping bed bugs in apartments. J. Econ. Entomol. 104(1): 274-278.

Wang, D., C. Wang, G. Wang, C. Zha, A.L. Eiden and R. Cooper. 2018. Efficacy of three different steamers for control of bed bugs (Cimex lectularius L.). Pest Manag. Sci. 74(9): 2030-2037.

Zhang, X.C., M. Jiang, Y.N. Zang, H.Z. Zhao, C.X. Liu, B.R. Liu, H. Xue, C. Schal, X.M. Lu, D.Q. Zhao and X.X. Zhang. 2022. Metarhizium anisopliae is a valuable grist for biocontrol in beta-cypermethrin-resistant Blattella germanica (L.). Pest Manag. Sci. 78(4): 1508-1518.