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Editorial: Latest research advances in biology, ecology, and integrated pest management of invasive insects

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Editorial on the Research Topic
Latest research advances in biology, ecology, and integrated pest management of invasive insects

Insect pests pose a significant threat to crop production and food security, being a leading cause of crop loss. This threat is amplified by the pests' ability to spread, driven by their increasing tolerance to environmental extremes and their capacity to develop resistance to insecticides. Invasive insect species present an even greater challenge to agricultural production (Qureshi et al., 2009; Clarke and McGeoch, 2023; Subedi et al., 2023), as they disrupt native communities and trigger both bottom-up and top-down effects within local ecosystems. Over the past century, the number of invasive insect species affecting agriculture has risen significantly, fueled by climate change and the intensification of global trade (Baloch et al., 2020; Hulme, 2021). The negative ecological impacts of these species can occur soon after their introduction or take years to manifest, depending on their ability to adapt through changes in phenotypic plasticity, reproductive success, and the absence of natural enemies.

While major agricultural producers are significant sources of invasive species, consumer nations are often more vulnerable to these pests (Paini et al., 2016). For example, the fall armyworm (*Spodoptera frugiperda*; Lepidoptera: Noctuidae) and the spotted-wing drosophila (*Drosophila suzukii*; Diptera: Drosophilidae) have spread widely due to international trade. Both pests are highly polyphagous, feeding on a wide range of economically important crops. Their success is largely attributed to the absence of natural enemies in new environments and their high reproductive potential. Additionally, favorable climatic conditions and abundant host plants facilitate rapid breeding, leading to multiple generations per year (Asplen et al., 2015; Day et al., 2017).

Given the additional threat due to climate change, effective and sustainable strategies are urgently needed to control invasive insect pests and ensure agricultural sustainability, food security, and ecosystem health. Assèdé et al. analyzed studies published between 1991 and 2024 and found that insecticide application remains the primary method for controlling both invasive and local insect pests in sub-Saharan Africa. While insecticides are favored for their rapid action and effectiveness, their widespread use carries significant risks, including human health threats, environmental degradation, disruption of beneficial agricultural functions (such as pollination and biological control), secondary pest outbreaks, and, most critically, the development of resistance (Nicolopoulou-Stamati et al., 2016). To mitigate these risks, sustainable approaches such as Integrated Pest Management (IPM) are being explored. These strategies combine biological control using indigenous or exotic natural enemies, the use of target-specific insecticides, water harvesting, drip irrigation, cultivation of resistant plant varieties, and agroecological practices.

Successful management of invasive pests depends on early detection and accurate identification. Common monitoring methods include pheromone traps, panel traps, visual sampling, extraction techniques (such as sugar, salt, freezing, and heat extraction), sweep-netting, and fruit damage assessment. Early detection provides crucial information for pest management decisions. For example, Babu and Sial validated a novel vacuum extraction protocol for sampling *D. suzukii* larvae. Tested at two blueberry production sites, this method shows promise as a tool for growers to manage *D. suzukii* more effectively.

In small-scale production systems, mechanical control can effectively reduce invasive insect populations. For example, African farmers often handpick larvae and crush egg masses and neonate larvae of *S. frugiperda* in small maize fields. These practices help reduce pest populations locally and prevent mature individuals from dispersing to larger production areas (Togola et al.).

Understanding the bottom-up effects between plants and insects is crucial for effective insect management. For instance, activators of plant defenses can play a key role in IPM programs, although their full potential has yet to be realized. Maldani et al. investigated the use of phytohormones to activate plant defenses in wheat against the Hessian fly, *Mayetiola destructor*, and found that the effectiveness of these treatments depended on the timing of application and larval density. Similarly, Quadrel et al. tested commercial elicitors, including those activating the salicylic acid and jasmonic acid defense pathways in plants, but found no effect as a standalone strategy on repelling or deterring oviposition or inducing larval toxicity in *D. suzukii*.

In conclusion, ensuring safe and sustainable agricultural production remains a global challenge, as crops face multiple, synergistic threats from both native and invasive pests. The focus is shifting toward reducing insecticide use to minimize health and environmental risks, while developing practical, environmentally safe, and cost-effective control methods. IPM offers a promising alternative, aiming to reduce reliance on insecticides. Numerous innovative strategies have been developed to meet the evolving needs of modern agriculture, but further research is essential for their full implementation. Moreover, the limited understanding of how environmental conditions influence new control methods presents a significant challenge. Studying pest invasiveness, understanding their biology and ecology, identifying vulnerable life stages, and assessing how various agronomic practices influence insect populations and damage are crucial for developing effective and sustainable IPM strategies (Dara, 2021).

Author contributions

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