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Entomologia Experimentalis et Applicata

INTRODUCTION

Special Issue: Fall Armyworm

Biology of fall armyworm – an introduction

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Abstract

Fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), is a voracious pest of various crops, such as maize, rice, and sugarcane. Originally from the tropical and subtropical regions of the Americas, it recently spread around the world. As populations can be resistant to pesticides, integrated pest management (IPM) is important, relying on a combination of chemical, physical, and biological control. This special issue of Entomologia Experimentalis et Applicata includes both fundamental and applied studies on fall armyworm biology, monitoring, and control, setting the stage for the development of effective, sustainable strategies to protect crops against fall armyworm, both in its native range and in areas where it has invaded.

KEYWORDS

biological control, fall armyworm, integrated pest management, invasive species, Lepidoptera, monitoring, Noctuidae, pest, pesticide resistance, special issue, *Spodoptera frugiperda*

INTRODUCTION

Fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), is a voracious pest of various crops, especially grasses, such as maize, rice, and sugarcane, but also vegetables and cotton (Figure 1). Originally from the tropical and subtropical regions of the Americas, it recently spread around the world: it was found in São Tomé and Príncipe, Benin, Nigeria, and other African countries in 2016; in India in 2018; in China, South Korea, Japan, and other Asian countries in 2019; and in Australia in 2020 (Kinkar et al., 2020; CABI, 2022). In China, it has infested many provinces, from south and southwest regions to the northeastern 'corn belt'. Recently, the species was also found in Cyprus (EPPO, 2023). Fall armyworm adults can migrate long distances, which is likely an important factor in its success as a pest (Westbrook et al., 2016). In addition, larvae can disperse by crawling or ballooning (i.e., aerial dispersal using silk threads) (Sokame et al., 2020; Malaquias et al., 2021).

Fall armyworm populations can be resistant to a number of pesticide active substances (Van den Berg & du Plessis, 2022). Therefore, integrated pest management (IPM) is important, relying on a combination of chemical, physical, and biological control. Commonly used tools for fall armyworm control consist of insecticides, including Bt products, and genetically modified Bt crops (Malaquias et al., 2021; Zuim et al. 2023), and the search for new insecticides continues (Mesurado et al., 2021). Push-pull companion cropping is also being investigated as a potential control method (Cheruiyot et al., 2021). Various compounds of the female's sex pheromones, released to attract conspecific males, have been identified, and a commercial lure is available to monitor and/or trap fall armyworm (Unbehend et al., 2014; Meagher Jr et al., 2019; Cortez-Mondaca et al., 2023; Saveer et al., 2023).

Interestingly, fall armyworm is able to detoxify specific defense compounds in maize (Glauser et al., 2011), as well as suppress maize defense mechanisms (de Lange et al., 2020). Indeed, its gut microbes impact defense responses (Acevedo et al., 2017). Therefore, fall armyworm's microbiota may also contribute to its status as an important pest world-wide (Costa et al., 2021). Interactions with other insects, such as competing herbivores and natural enemies, affect fall armyworm performance (Costa et al., 2022). In its native region, fall armyworm is a host to a large variety of parasitoid wasps and flies (von Mérey et al., 2012; Barreto-Barriga et al., 2021; Traine et al., 2021), some of which are commercially available (Vargas et al., 2021). The species is also frequently attacked by predators, fungi, viruses, and entomopathogenic nematodes (Molina-Ochoa et al., 2003; Fallet et al., 2022). It is important to monitor the presence of natural enemies in invasive areas, to assess their potential as biological control agents (Agboyi et al., 2020; Fallet et al., 2022).

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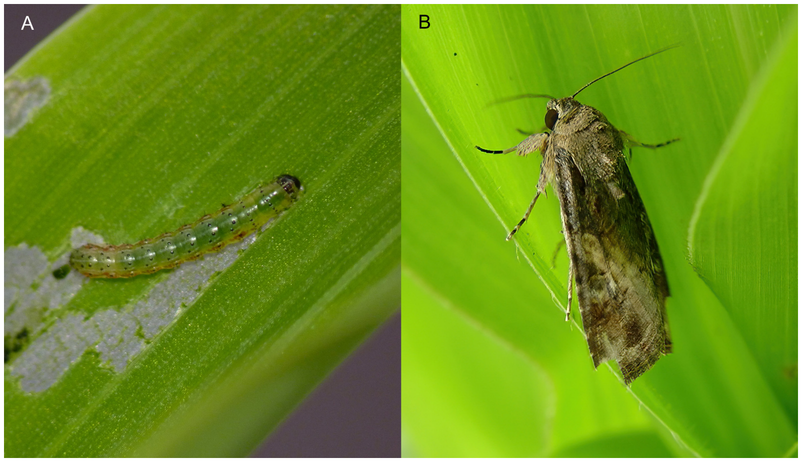

FIGURE 1 *Spodoptera frugiperda* (A) larva and (B) adult on a maize plant. Photos by (A) Matthias Held and (B) Fernando Bahena Juárez.

THIS SPECIAL ISSUE

This special issue of Entomologia Experimentalis et Applicata includes both fundamental and applied studies on fall armyworm biology, monitoring, and control.

Fall armyworm can feed on over 350 plant species and is a pest of many crops. Lu et al. (2023) assessed the feeding preference of fall armyworm larvae between maize and five other cereal crops. The insect preferred maize and sorghum over the other plants, and performance was overall best on maize, but the insect was also able to complete its life cycle on the other plants. Its polyphagous nature is thought to contribute to its pest status.

Chen et al. (2023) used 16S rRNA amplification sequencing to characterize the microbiome of fall armyworm larvae, pupae, and adults. They found that the bacterial diversity of young larvae was highest, and overall, Proteobacteria and Firmicutes were most abundant. Diet had important effects on microbial diversity, as insects fed on maize had a higher diversity than insects fed on artificial diet. This study shows the hidden complexity of living organisms – microbes play an important role in insect biology.

Guo et al. (2023) studied the flight mechanisms of fall armyworm adults. The insect has a strong flight capacity, and appears well adapted to rapidly change its trajectory, which may help escape from predators. Interestingly, mating reduced flight capacity in females, suggesting a trade-off between flight and reproduction. Flight characteristics may partially explain the success of fall armyworm as a pest.

Climate change may increase the number, as well as the severity of heat waves. Mbande et al. (2023) studied the effects of simulated extreme weather conditions on low and high temperature tolerance and reproduction of fall armyworm adults, and found that heat shock increased heat tolerance, but decreased cold tolerance. Also, heat shock decreased fecundity and egg hatching success. These results show that climate change may have unexpected effects on the spread of fall armyworm and its status as a pest; therefore, the species should be monitored continuously.

As commercially available fall armyworm pheromone traps attract many non-target moths in Japan, Tabata et al. (2023) aimed to improve them. They discovered trace amounts of (*Z,E*)-9,12-tetradecadienyl acetate in pheromone extracts, and adding this compound to four-component pheromone traps [(*Z*)-9-tetradecenyl acetate, (*Z*)-11-hexadecenyl acetate, (*Z*)-7-dodecenyl acetate, and (*Z*)-9-dodecenyl acetate], enhanced the attractiveness and selectivity of the lure, thereby improving fall armyworm monitoring.

In a pro-active attempt to catch a fall armyworm invasion early, Szanyi et al. (2023) deployed commercially available fall armyworm pheromone traps in Central Europe, where the pest currently does not occur. Indeed, the authors did not find fall armyworm in the traps, but they found a number of non-target moths, which could easily be distinguished from fall armyworm if growers and other professionals are trained in basic moth identification. Starting this training now would ensure a rapid response to potential fall armyworm establishment in Europe.

In a landscape-scale study in Kenya, Salzberg et al. (2023) assessed the effects of landscape complexity (i.e., natural area surrounding crop fields) in combination with push-pull companion cropping on fall armyworm egg predation. The authors found no significant effect of companion cropping, but increased landscape complexity led to larger female predatory lady beetles, which consequently led to increased egg predation in the laboratory. As just the size increase could not explain the increase in egg predation, this indicates that landscape complexity affected predator behavior. This study suggests that preserving natural areas surrounding farms may increase the levels of natural pest control, but also emphasizes that the same pest management approach may have different outcomes on different farms, depending on details of the environmental characteristics.

Overall, the knowledge provided in this special issue will set the stage for the development of effective, sustainable strategies to protect crops against fall armyworm, in

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its native range as well as in areas where it already has invaded or may soon invade.

AUTHOR CONTRIBUTIONS

Elvira de Lange: Conceptualization (supporting); writing – original draft (lead); writing – review and editing (supporting). **Yutao Xiao:** Conceptualization (supporting); writing – original draft (supporting); writing – review and editing (supporting). **Leo W Beukeboom:** Conceptualization (lead); writing – original draft (supporting); writing – review and editing (lead).

DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

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