



## Research Note

# First report of *Tetrastichus howardi* (Olliff) and *Chelonus formosanus* Sonan as parasitoids of fall armyworm, *Spodoptera frugiperda* (J.E. Smith), in Pakistan

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**ABSTRACT:** Fall armyworm, *Spodoptera frugiperda* (J.E. Smith), an invasive agricultural pest, causes substantial economic losses in Pakistan. This study reports the first record of *Tetrastichus howardi* (Olliff) and *Chelonus formosanus* Sonan as natural enemies parasitising *S. frugiperda* within the country. Parasitoids were collected from infested maize fields and identified through morphological analysis. This discovery enhances our understanding of the natural enemy complex associated with *S. frugiperda* in Pakistan and provides a foundation for investigating their potential as biological control agents. These findings underscore the potential of these parasitoids as components of integrated pest management systems to diminish reliance on chemical insecticides and foster sustainable agricultural practices.

**KEYWORDS:** Biological control, *Chelonus formosanus*, maize, Pakistan, *Spodoptera frugiperda*, *Tetrastichus howardi*

(Article chronicle: Received: 05-08-2024; Revised: 17-09-2024; Accepted: 19-09-2024)

Originating from the Americas, the polyphagous fall armyworm, *S. frugiperda*, has rapidly spread worldwide (Sparks, 1979; Sagar *et al.*, 2020). Its voracious feeding and adaptability have caused substantial economic losses to maize and other crops worldwide. Since its incursion into Africa around December 2015, the pest's rapid spread has posed severe challenges to food security and livelihoods (Goergen *et al.*, 2016).

Pakistan, a major agricultural producer, has suffered significant losses due to the *S. frugiperda* infestation. The pest's rapid adaptation necessitates sustainable management strategies (Padhee *et al.*, 2019). Biological control is a promising strategy, but the overuse of chemical insecticides has disrupted natural enemy communities, hindering its effectiveness (Desneux *et al.*, 2007; Khan *et al.*, 2020).

Identifying the natural enemies associated with *S. frugiperda* is essential for developing effective biological control programs. While research has documented parasitoid fauna in the pest's native and introduced ranges, information on its natural enemies in Pakistan remains limited. This study identifies key parasitoids of *S. frugiperda* in Pakistan,

contributing to the development of sustainable and integrated pest management strategies.

Field surveys targeting *S. frugiperda* and its potential natural enemies were conducted from March to September 2023 across major maize-growing provinces in Sindh, Punjab, Balochistan, and Khyber Pakhtunkhwa, Pakistan. These regions were selected to represent a range of agroecological conditions influencing maize cultivation and pest dynamics. Collected life stages of *S. frugiperda* (eggs, larvae, and pupae) were transferred to appropriate containers and reared on a natural diet under control conditions (temperature of  $25 \pm 2^\circ\text{C}$ ,  $70 \pm 5\%$  relative humidity) at the Riaz Mehmood Insect Biological Control Laboratory, allowing direct observation and study.

The collected specimens were carefully identified to the species level using standard taxonomic keys. Morphological features were examined in detail under a ZSK 745T microscope, with high-quality images captured using a Miji digital camera for accurate identification and documentation. To enhance taxonomic accuracy, a subset of specimens was submitted to Parasitic Hymenoptera specialists at the Natural

History Museum in London for species determination. Voucher specimens of *T. howardi* (Olliff) and *C. formosanus* Sonan were deposited at the National Insect Museum, CABI Regional Bioscience Centre in Rawalpindi, Pakistan, for future research and reference.

This study documents the first occurrence of *T. howardi* (Olliff) (Hymenoptera: Eulophidae) and *C. formosanus* Sonan (Hymenoptera: Braconidae) parasitizing the invasive fall armyworm, *Spodoptera frugiperda*, within Pakistan. Field surveys across major maize-growing regions revealed a diverse parasitoid community targeting various host life stages.

*Tetrastichus howardi* was identified as a pupal parasitoid and was recorded exclusively in District Rawalpindi, Punjab Province (GPS: 33°38'41.0"N 73°04'59.0"E), thereby expanding its known geographical range. It is a polyphagous, gregarious pupal parasitoid attacking a wide range of lepidopteran hosts (Baitha *et al.*, 2004; La Salle & Polaszek, 2007; Rodrigues *et al.*, 2021). *T. howardi*, a key natural enemy thriving in tropical and subtropical regions, effectively controls a range of lepidopteran pests such as sugarcane borer (*Diatraea saccharalis*), cotton bollworm (*Helicoverpa armigera*), diamondback moth (*Plutella xylostella*), and fall armyworm (*S. frugiperda*) (La Salle & Polaszek, 2007; Silva-Torres *et al.*, 2010; Cruz *et al.*, 2011; Oliveira *et al.*, 2016). Tang *et al.* (2022) observed a 4.5% parasitism rate of *S. frugiperda* pupae by *T. howardi* in Hainan Province, China. This parasitoid exhibits favourable characteristics for biological control, including facile propagation and robust thermal adaptability. Yan *et al.* (2021) documented a maximum of 60 wasp eggs within a single host pupa. As both a primary and facultative hyperparasitoid, *T. howardi* offers versatility in biological control strategies. *T. howardi* has exhibited promise as a biological control agent, as evidenced by its successful application against the sugarcane borer (*Chilo partellus*) in South Africa (Kfir *et al.*, 1993). To fully realize its potential for managing *S. frugiperda*, comprehensive research is imperative to quantify its impact on this specific pest. A thorough understanding of its biology, ecology, and the development of efficient mass-rearing protocols are critical for optimizing its efficacy in biological control programs.

*Chelonus formosanus* was identified as an egg-larval parasitoid of *Spodoptera frugiperda*. This species was recorded solely in District Haripur, Khyber Pakhtunkhwa, Pakistan (GPS: 33°59'19.3"N 73°01'51.2"E), marking a new host record for *C. formosanus* in the country. Several *Chelonus* species, including *C. formosanus*, have been documented in both the Neotropical and Oriental regions (Yu *et al.*, 2015; Gupta *et al.*, 2019; Calcetas *et al.*, 2023, 2024).

The broad host range of *Chelonus* species, predominantly targeting lepidopteran pests, has been well-documented. These parasitoids have proven effective in managing a wide range of economically important lepidopteran pests, such as the common cutworm (*Spodoptera litura*), beet armyworm (*Spodoptera exigua*), and corn earworm/cotton bollworm (*Helicoverpa armigera*). Notably, laboratory-reared *Chelonus* spp. have been successfully employed as biological control agents against a wider spectrum of lepidopteran pests such as *Batrachedra arenosella*, *Earias vittella*, *Pectinophora gossypiella*, *Prays oleae*, *Spodoptera littoralis* (Calcetas *et al.*, 2023, 2024). Successful laboratory rearing of *Chelonus* spp. underscores their potential as biological control agents. To fully harness the potential of two newly recorded parasitoids, *T. howardi* and *C. formosanus*, comprehensive studies on their life history, mass rearing, host specificity, and optimal release strategies are being conducted at CABI's Riaz Mehmood Insect Biological Control Laboratory.

Field surveys identified additional parasitoid species previously associated with *Spodoptera frugiperda*, including the egg parasitoids *Trichogramma chilonis* Ishii (Hymenoptera: Trichogrammatidae) (Terefe *et al.*, 2023), *Telenomus remus* Nixon (Hymenoptera: Scelionidae) (Kenis *et al.*, 2019), and the larval parasitoid *Microplitis manilae* Ashmead (Hymenoptera: Braconidae). This augmentation of the parasitoid complex is a promising development for biological control strategies. Preliminary observations suggest that *T. chilonis* and *T. remus* may exhibit significant parasitism rates on *S. frugiperda* eggs, corroborating findings from other regions (Abang *et al.*, 2021). Previous studies have reported a diverse assemblage of parasitoids attacking *S. frugiperda* in field populations (Shylesha *et al.*, 2018; Gupta *et al.*, 2019). Parasitoids targeting multiple life stages, such as *M. manilae*, *T. howardi*, and *C. formosanus*, offer a comprehensive approach to pest management (Moghaddam *et al.*, 2023). By conserving and augmenting these beneficials, reliance on chemical inputs can be significantly reduced, promoting sustainable agricultural practices. This aligns with integrated pest management principles, which prioritize ecological balance and environmental stewardship (Dara, 2019).

## CONCLUSION

The discovery of *T. howardi* and *C. formosanus* as natural enemies of *S. frugiperda* in Pakistan marks a crucial advancement in sustainable pest management. Ongoing studies at CABI's Riaz Mehmood Insect Biological Control Laboratory are focused on their life history, mass rearing, host specificity, and release strategies to maximize their potential for controlling this invasive pest.

## ACKNOWLEDGEMENTS

We extend our gratitude to the staff of the Riaz Mehmood Insect Biological Control Laboratory (CABI-Pakistan) for their invaluable assistance with specimen identification and analysis. We also thank the dedicated field teams for their diligent sample collection. This research was made possible through the generous financial support of the Foreign, Commonwealth, and Development Office (FCDO), UK; the Directorate-General for International Cooperation (DGIS), Netherlands; the European Commission Directorate-General for International Cooperation and Development (DEVCO); and the Swiss Agency for Development and Cooperation (SDC). We also acknowledge CABI's PlantwisePlus Programme for facilitating this research.

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