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# Performance of the native predatory bug, *Eocanthecona furcellata* (Wolff) (Hemiptera: Pentatomidae), on the fall armyworm, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae), and its limitation under field condition

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## Abstract

The invasive fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) was reported recently in India, in 2018, destroying food and fodder crops. *Eocanthecona furcellata* (Wolff) (Hemiptera: Pentatomidae), the native pentatomid predatory bug, expanded its host range by predating on larvae of FAW. The incidence of *E. furcellata* started during the 36th meteorological standard week and reached its peak population (3.4 adult and 2.4 egg mass/m$^2$) during the 40th MSW. The predator adult female was capable of feeding on 126 ± 4.76, 88 ± 1.37, and 69 ± 1.32 larvae of II, IV, and VI instars of *S. frugiperda*, respectively. The field performance of *E. furcellata* was narrowed due to the presence of platygastroid secondary parasitoids viz., *Gryon* sp., *Telenomus* sp., and *Trissolcus* sp. where rate of parasitism due to respective parasitoids reached up to 100, 91.80, and 77.68% Autumn 2019.

**Keywords:** *Spodoptera frugiperda*, *Eocanthecona furcellata*, Performance, Rate of parasitism

## Background

Invasive insect species poses major challenges to mankind by threatening food security, agricultural biodiversity, and human and animal health resulting in significant economic losses (Pimentel 2014). The fall armyworm (FAW) *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) is a highly polyphagous, invasive lepidopteran pest native to tropical and subtropical regions of America. It has invaded the African continent in 2016 (Goergen et al. 2016) and later spread to countries in South and South-East Asia including India, Sri Lanka, Bangladesh, China, Thailand, and Indonesia causing significant damage to food and fodder grasses (Sharanabasappa et al. 2018; Sun et al. 2019). Considering the ideal climatic conditions and year round availability of suitable host plants, the insect can complete several generations and the pest likely become endemic to the Indian subcontinent (Montezano et al. 2018).

Use of biocontrol agents has become one of the most feasible and economic tool to manage FAW. A wide range of natural enemies attacking FAW including parasitoids, arthropod predators, and entomopathogens were reported in India (Shylesha and Sravika 2018; Sharanabasappa et al. 2019). It is highly likely that native bio-agents of *Spodoptera* spp. might have expanded their host range by attacking *S. frugiperda*, a closely related foreign born insect

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**Fig. 1** *Eocanthecona furcellata* adult feeding on larvae of *S. frugiperda* (photo taken during the field survey: 16 October 2019)

(Sharanabasappa et al. 2019). The predators of FAW reported in India are generalist predators that attack many other caterpillars. Among them, the pentatomid bug, *Eocanthecona furcellata* (Wolff) (Hemiptera: Pentatomidae) is an effective predatory species widely distributed in Southeast Asian countries including India, China, Indonesia, and Japan (Shylesha and Sravika 2018) and commonly observed in cotton and chickpea ecosystem (Nyunt 2008). In India, it has been identified as an important predator on *Pericallia ricini* (Lepidoptera: Arctiidae) (now known as *Olepa ricini* (Fabricius) on cotton (Nancy Shophiya and Sahayaraj 2014), *Latoia lepida* (Lepidoptera: Limacodidae) (now known as *Parasa lepida* (Cramer) (Senrayan 1988), *Maruca vitrata* (Fabricius) (Lepidoptera: Pyralidae), and *Spodoptera litura* Fabricius (Lepidoptera: Noctuidae) (Tiwari et al. 2017). The incidence of *E. furcellata* and feeding on FAW was observed (Fig. 1) at the Indian Council of Agricultural Research—Indian Grassland and Fodder Research Institute, Jhansi, Uttar Pradesh (25.526057 N, 78.571231 E), during Autumn 2019.

## Materials and methods

In the present study, seasonal incidence of *E. furcellata* at ICAR-IGFRI, Jhansi, by visual counting the number of the predator, was recorded, and its egg masses in 1 $m^2$ area in 5 random locations were replicated thrice. To study the predatory potential on *S. frugiperda*, the experiment was conducted at ICAR-National Bureau of Agricultural Insect Resources, during 2018–2019. The adults of *E. furcellata* were collected from maize fields and kept in plastic jar (30 × 25 cm) with dried castor leaf as a substrate for oviposition. Four nymphal instars of the predator (excluding first nymphal stage: Zoophytophagous nature) were used to study predation rate on *S. frugiperda*. The individual nymphal instar ($n$ = 10) of predatory bug viz., II, III, IV, and V, were placed in separate plastic container (90 mm × 50 mm) along with 20 FAW larvae (II, IV, and VI instar) in each container for all the nymphal stage used. Before releasing of FAW larva, the head was crushed to stops their movement during predation. Numbers of larvae consumed by each nymphal instar were recorded daily, and fresh larvae were provided for further feeding till the end of each

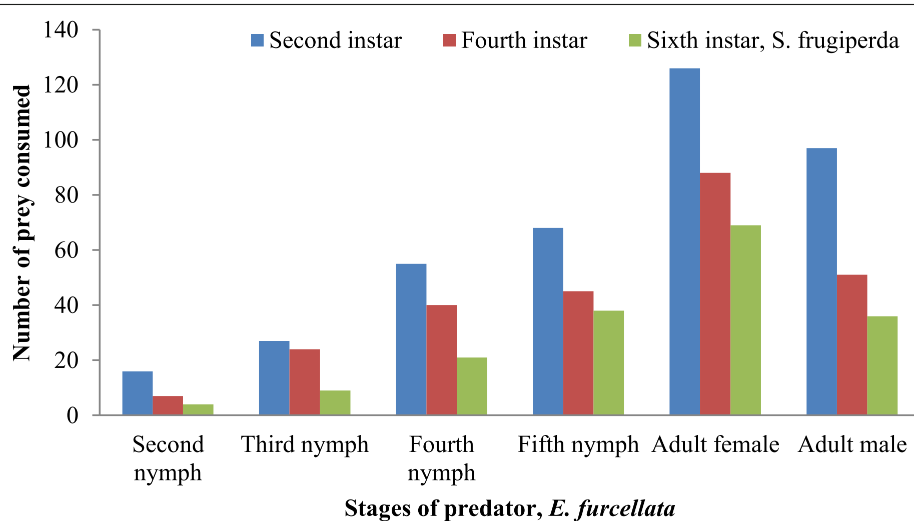


**Fig. 2** Feeding potential of the predatory bug. *E. furcellata* on different larval instars of *S. frugiperda*

nymphal instar of predator. Similar setup was repeated to study the feeding potential of *E. furcellata* adult, and the predation rate was recorded for the total adult longevity period (male 10 days and female 20 days). Each experiment was replicated thrice. During field visits (October 2019), the egg mass of *E. furcellata* (the eggs are bright black in color with shiny silver coating on surface; 12 spines surround the round top surface) was collected from maize field of IGFRI, Jhansi, and organic field of University of Agricultural Sciences, Bengaluru (13.082713 N, 77.576732 E), kept in laboratory for emergence. Normality and homogeneity check of the collected data were done, using SAS version 9.3. One way ANOVA was constructed using SAS and significance level judged at $P$ value < 0.05.

## Results and discussion

The incidence of *E. furcellata* started during the 36th meteorological standard week. The mean adult population and egg mass of *E. furcellata* were 1 and 0.6/m$^2$, respectively, during the 37th meteorological standard week (MSW) and reached a peak of 3.4 (adult) and 2.4 (egg mass)/m$^2$ during the 40th MSW. Thereafter, the population started declining and attained lowest of 0.6 (adult) and 0.2 (egg mass/m$^2$) during the 47th MSW and disappeared during the 48th MSW, which coincided with the harvesting of maize crop in the field. Similar population dynamics of the predatory bug were reported by Snehel et al. (2017).

As illustrated in Fig. 2, adults showed more consumption rate to the nymphs under laboratory conditions (df = 2, 27; $P$ < 0.0001; $F$ value: male = 733.31; female = 432.40; 2nd nymph = 263.2; 3rd nymph = 261.56; 4th nymph = 496.14). The predation rate of the adult female was higher than the male. It consumed 126 ± 4.76, 88 ± 1.37, and 69 ± 1.32 of 2nd, 4th, and 6th instars of *S. frugiperda*, respectively. Among the nymphs, the trend of predation gradually increased from the 2nd nymphal instar to the 5th in all the exposed larval instars. The 5th nymph has more potential than the rest of instars. It consumed 68 ± 5.41, 45 ± 0.71, and 38 ± 1.03 larvae of 2nd, 4th, and 6th instars of FAW. Obtained results are similar to those of Tuan et al. (2016) who reported that the female (N2–N3, N4, and N5) nymphs of *E. furcellata* consumed 7.6, 19.3, and 57.1 larvae of *S. litura*, respectively. The higher predation rate in female might be required to prepare for oogenesis and longevity in the adult stage. There were many reports of *E. furcellata* feeding on other lepidopteran caterpillars; however, literature on FAW is lacking hence the larvae of different taxonomic group used for comparisons.

A total of 6 egg masses of *E. furcellata* were collected from each location (Jhansi and Bengaluru), where number of eggs varied from 23 to 61. Among the egg masses collected from Jhansi, 4 egg masses were found parasitizing with *Telenomus* sp. (Hymenoptera: Platygastridae) (Fig. 3a); the remaining 2 were parasitized by *Gryon* sp. (Hymenoptera: Platygastridae) (Fig. 3b). The percent parasitism of *Telenomus* sp. varied from 78.26 to 91.80%, whereas percent parasitism by *Gryon* sp. was 65.11 and 71.69, respectively, from 2 egg masses. On the other hand, among the egg masses collected from Bengaluru, one egg mass was parasitized by *Trissolcus* sp. (Hymenoptera: Scelionidae) (Fig. 3c) and 2 egg masses were parasitized by *Gryon* sp. The percent parasitism of *Trissolcus* sp. was 77.78% and 85.18 and 100% by *Gryon*

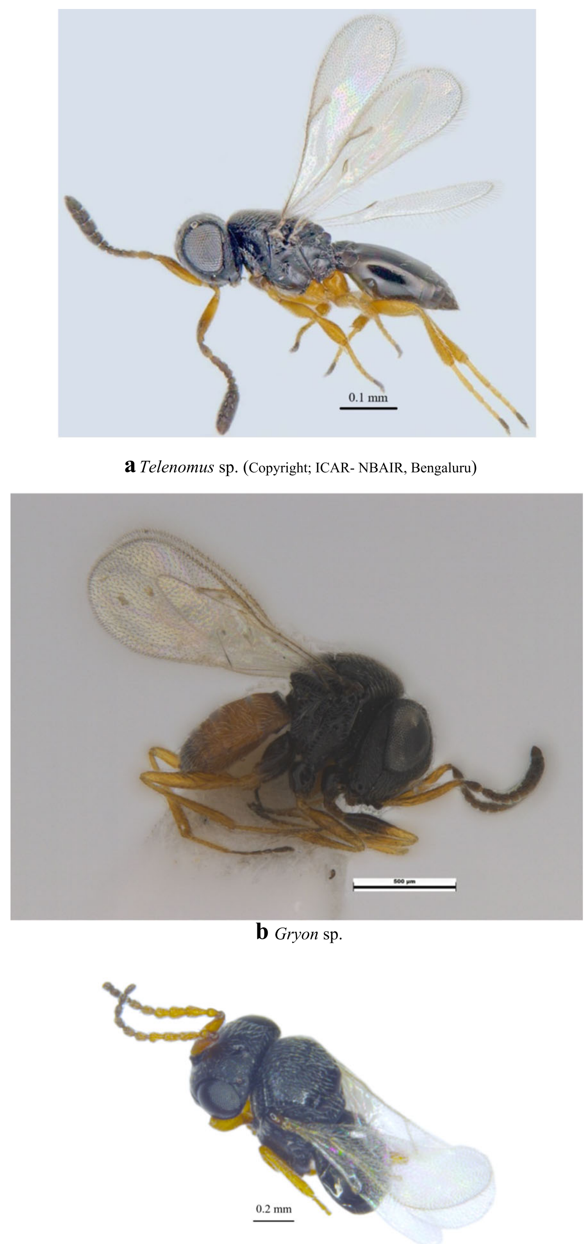


**Fig. 3** **a** *Telenomus* sp. (copyright; ICAR-NBAIR, Bengaluru). **b** *Gryon* sp. **c** *Trissolcus* sp.

sp., respectively, from 2 egg masses. *Gryon* sp. was the common egg parasitoid observed in both locations. Interestingly, all the adult parasitoids (*Gryon* and *Trissolcus*) emerged from egg masses were males, except for *Telenomus* sp. where females also were obtained.

The role of insects in any ecosystem has always varied depending on human choice, because *Gryon* sp., *Trissolcus* sp., and *Telenomus* sp. were important egg parasitoids commonly used around the world for the management of hemipteran bugs (Cornelius et al. 2016; Buffington et al. 2018); however, in the present study, they were found parasitizing eggs of the predatory bug, *E. furcellata*, which plays a role of predator in maize ecosystem. The result of the current study indicates the role of *E. furcellata*, as a biocontrol agent; however, under field conditions, it is assumed that its potential might be limited by existing secondary parasitoids. In the current study, *E. furcellata* is not only effective in reducing FAW but also in managing other lepidopteran pests of maize like *Helicoverpa armigera* (Hübner), *Spodoptera litura*, and *Ostrinia furnacalis* (Guene) (Semillano and Corey 1992; Nebapure and Meena 2011). However, the efficiency of the predator is not fully expressed in nature due to existing native secondary parasitoids like *Gryon* sp., *Trissolcus* sp., and *Telenomus* sp. The presence of such secondary parasitoids in nature may limit the potential of the predator. Therefore, further field studies are required to confirm the hypothesis and for better understanding the functioning of the food web, as multi-trophic level systems where secondary parasitoids are common, even in simple agricultural ecosystems such as greenhouses.

### Abbreviations
FAW: Fall armyworm; ICAR: Indian Council of Agricultural Research; IGFRI: Indian Grassland and Fodder Research Institute; MSW: Meteorological standard weeks; Fig.: Figure; NBAIR: National Bureau of Agricultural Insect Resources; UAS, GKVK: University of Agricultural Sciences, Gandhi Krishi Vigyana Kendra

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### Authors' contributions
KMC and AS: conceptualization, experimentation, and original draft writing. MHS: data curation. AG: identification of hyperparasitoids and manuscript editing. BHA and SA: statistical analysis and reviewing and editing. All authors read and approved the final manuscript.

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The authors declare that they have no competing interests

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