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Status of Natural Enemies and Entomopathogens on New Invasive Pest *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) under Maize Ecosystem in Indian Subcontinent

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ABSTRACT

The pests' natural enemies were explored by collecting FAW eggs and larvae from maize fields. The survey also revealed natural parasitism by egg parasitoids viz., *Telenomus* sp. (Hymenoptera: Platygastridae) and *Trichogramma* sp. (Hymenoptera: Trichogrammatidae), gregarious larval parasitoid *Glyptapanteles creatonoti* (Viereck) (Hymenoptera: Braconidae) solitary larval parasitoid *Campoletis chlorideae* Uchida (Hymenoptera: Ichneumonidae), and a solitary indeterminate larval-pupal (Hymenoptera: Ichneumonidae: Ichneumoninae) parasitoid. *Spodoptera frugiperda* is the first host record for *G. creatonoti* across the globe. The parasitiods were raised in the laboratory for emergence, recognition and effectiveness as natural enemies. *Cotesia* or *Apanteles* spp. were concluded to occur since emerged. Besides these, other commonly found bioagents viz., *Forficula* sp. (Dermaptera: Forficulidae) and entomopathogenic fungus *Nomuraea rileyi* (Farl.) Samson was also collected in large numbers. Therefore, the occurrence of *Spodoptera frugiperda* natural enemies in India represents for advocacy campaign to include their use into IPM strategies that enhance and permit bio agents to boom for control of fall armyworm.

Keywords Natural enemy, Entomopathogen, Maize, *Spodoptera frugiperda,* Invasive pest, Predator, Parasitoid.

INTRODUCTION

Fall armyworm belongs to the tropical region of the western hemisphere from the USA to Argentina. *Spodoptera frugiperda* (JE Smith) (Lepidoptera: Noctuidae) is known as the very significant pest of *Zea mays* in Brazil, the third largest corn producer in the world after the USA and China. In Brazil alone, expenditure to control the *Spodoptera frugiperda* on maize surpassed 600 million dollars yearly. Until 2015, pest has not been detected in any remaining part except in USA. In 2016, FAW was observed in

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Africa give rise to serious loss on maize crop (Goergen *et al.* 2016).

It is autoecious in character (Hoy 2013) with host preference noticed more than 353 plants of 76 different families, majorly Poaceae (106), Asteraceae (31) and Fabaceae (31), (Montezano *et al.* 2018). The caterpillars devour virtually all the vegetation in their route and the higher damage is due to eating on the foliage (Bista *et al*. 2020). The pest has maximum fecundity that enhances species population in a very little period (Montezano *et al,* 2018). In Asia, the establishment and widespread presence of FAW was noticed in Karnataka state, India at college of Agriculture, Shivamogga in May 2018 for the first time (Sharanabasappa *et al.* 2018). Then, it spreads to different tropical states of India like Bihar, Chhattisgarh, Gujarat, Maharashtra, Odisha, West Bengal etc. causing devas-tating damage within short duration (CABI 2020). Genetic homogeneity was discovered between *Spodoptera frugiperda* of India and South Africa with respect to the minute number of COI and Tpi halophytes suggesting their familiar place of genesis (Nagoshi *et al.* 2019).

Fall armyworm is a pest exhibiting plurivorous nature, with maximum of 80 host species, causing severe damage to cereals and vegetable crops (Goergen *et al,* 2016, Roger *et al.* 2017, Prasanna *et al.* 2018). The occurrence of this new invasive pest FAW was reported first of all from India by Sharanabasappa and Kalleshwaraswamy (2018) at Karnataka.

Different types of natural enemies

Natural enemies of the pest are available in the field or can be imported to control the invasion of the pest. Predators, parasitoids, and pathogens can be used as a natural enemy for the biological control of the pest. Predators eat pests as their prey. Ladybird beetles, earwigs, predatory bugs, soil surface beetles, and ants can be used as Predators for the control of FAW (FAO 2018). Parasitoids kill its host by feeding them. A group researchers suggested using *Telenomus remus* for the augmentation of parasitoids against FAW (Kenis *et al.* 2019). Pathogens like viruses, fungi, bacteria, nematodes, and protozoa act as biological control agents by causing the infection.

Table 1. Parasitoids of fall armyworm.

Sl. No.	Natural enemy	Nature
1	*Trichogramma pretiosum*	Females are egg parasitoids
2	*Telenomous remus* (Nixon)	Females are egg parasitoids
3	*Chelonus insularis cresson*	Females are egg/larval parasitoids
4	*Campoletis flavicincta* (Cameron) *Campoletis chloridae*	Females are larval parasitoids
5	*Cotesia icipie*	Females are larval parasitoids
6	*Habrobracon hebetor*	Females are larval parasit
7	*Winthemia trinitatis*	Females are larval parasitoids
8	*Lespesia archippivora*	Females are larval/pupal parasitoids
9	*Archytas marmoratus*	Females are larval/pupal para

Source: (Prasanna *et al.* (2018)

Parasitoids

They lay eggs on egg masses, larva and adult of fall armyworm and cease their growth by growing on them. Egg parasitoids are considered as most important among other biological control as they prevent any damage to crop and they can be easily grown in huge amount (Prasanna *et al,* 2018). *Cotesia icipie* is tremendously vital larval parasitoids which exhibits capacity to cause death over 60% of *Spodoptera frugiperda* (ICIPE 2018). Table 1 shows different parasitoids of the fall armyworm.

Predators

Predators are the natural enemies that destroy eggs, caterpillars, pupa or adult of the *Spodoptera frugiperda* during their lifecycle either as larva or adults (FAO 2018b). Ants, wasps and spiders are also most important predators of FAW eggs, larvae or pupa. Similarly, vertebrate predator like birds, skunks and rodents around the maize field is also beneficial as they feed larva as well as pupae of fall armyworm (Capinera 2000). Mostly fall armyworm reside inside whorl of maize where predatory earwig, *Doru lutepies* occurs throughout the life span of maize whose nymphs feed 8-12 larva daily and adult one consumes 10-21 larva daily (Reis *et al.* 1988). Different predators of FAW along with description is presented in Table 2.

Table 2. Predators of FAW.

Sl. No.	Predators	Scientific name	Description
1	Ladybird beetles	*Coleomegilla maculate Olla v-nigrum* *Cycloneda sanguinea* *Hippodamia convergens* *Eriopis connexa*	Both adults and larvae of ladybugs feed on eggs and young larvae of *Lepidoptera* including FAW
2	Ear wigs	*Doru luteipes* *Euborellia annulipes*	They are recognized as egg and larval predator of FAW
3	Ground beetle	*Calosoma granulatum*	They show predatory habit both as adult or larvae feeding on young FAW caterpillar
4	Assassin bugs	*Zelus longipes* *Zelus leucogrammus* *Zelus armillatus*	They feed on immature of FAW
5	Flower bugs	*Orius insidiosus*	They are predators of *Lepidopteran* eggs
6	Pirate bugs	*Nabis rugosus*	They are predators of small *Lepidopteran* larvae
7	Big-eyed bugs	*Geocoris punctipes*	They feed on immature of FAW
8	Spined soldier bug	*Podisus maculiventris*	Nymphs and adults mainly feed on *Lepidopt-ereran* larvae

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Source: (Prasanna *et al*. 2018, FAO 2018b).

Table 3. Biological control agents used for FAW management.

Type	Life stage	Natural enemy
Predators	Larvae	*Calleida decora, Calosoma alternans, Calosoma sayi Carabidae, Doru luteipes, Doru taeniatum, Ectatomma ruidum, Geocoris punctipes, Steopolybia pallipes, Podisus maculiventris*
Parasitoid	Egg	*Telonomus remus, Trichogramma achaeae, Trichogramma chilotraeae, Trichogramma pretiosum, Trichogramma rojasi*
Larvae		*Archytus incertus, Campoletis flavicincta, Cotesia marginiventris, Cotesia ruficrus, Euplectrus platypenae, Glyptapanteles creatonoti, Lespesia archippivora*
Eggs/Larvae		*Chelonus curvimaculatus, Chelonus insularis, Microchelonus heliopae*
Larvae/Pupa		*Archytus marmoratus*
Pathogens	Larvae	*Bacillus cereus, Bacillus thuringiensis, Bacillus thuringiensis alesti, Bacillus thuring-iensis darmstadiensis, Bacillus thuringiensis thuringiensis, Bacillus thuringiensis kurstaki, Granulosis virus, Nucleopolyhedrosis virus*
Egg/Larvae		*Beauveria bassiana, Metarhizium anisopliae*

Entomopathogens

Generally, plant pathogen (viruses, fungi, protozoa, bacteria and nematodes) are harmful to the crops and play vital role in reducing crop yield but some of them regulate FAW population in the field (Assefa and Ayalew 2019). Nuclear Polyhedrosis Viruses (NPVs) can be the useful and effective method against fall armyworm (de Romero *et al.* 2009). FAW is infected by Nuclear Polyhedrosis Viruses (NPVs) such as the *Spodoptera frugiperda* Multicapsid Nucleop-olyhedrovirus (SfMNPV), fungi like *Metarhizium anisopliae, Metarhizium rileyi, Beauveria bassiana, Protozoa* and bacteria like Bt bacteria (FAO 2018b).

Biopesticides based on bacteria *Bacillus thuring-iensis* (Bt), fungi, and baculovirus are found to be effective against FAW (FAO 2018). Virus based insec-ticides *S. frugiperda* multiple nucleopolyhedrovirus (SfMNPV) is specific to FAW only (CABI 2020). Table 3 represents various types of enmopathogens of all armyworm.

CONCLUSION

From India, Sharanabasappa and Kalleshwaraswamy (2018) observed the incidence of fall armyworm, *S. frugiperda* in mid-May in the maize fields at the College of Agriculture, University of Agricultural

and Horticultural Sciences (UAHS), Shivamogga, Karnataka. University of Agricultural Sciences (UAS-B) reported the pest incidence to the Karnataka State Department of Agriculture (Ganiger *et al.* 2018). ICAR- NBAIR team released pest alert at national level (ICAR-NBAIR 2018). Therefore, the key prominence at ICAR-NBAIR is on documenting the spread and identifying capable bio agents for biological management and investigating remaining congenial control application methods.

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