



## CANDIDATES FOR AUGMENTATIVE BIOLOGICAL CONTROL OF *SPODOPTERA FRUGIPERDA* IN KENYA, TANZANIA AND NEPAL

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### ABSTRACT

**Surveys of fall armyworm, *Spodoptera frugiperda*, in the maize fields in Kenya, Tanzania, and Nepal revealed the occurrence of egg parasitoids, *Trichogramma mwanzei* in Tanzania, *Trichogramma chilonis* in Kenya and Nepal, and *Telenomus remus* in Kenya, Nepal and Tanzania.**

**Key words:** Fall armyworm, parasitoids, field surveys, egg parasitism, *Telenomus remus*, *Trichogramma mwanzei*, *T. chilonis*, Kenya, Tanzania, Nepal, mtCO1, 28S rDNA, GenBank accessions

The fall armyworm (FAW) *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), an invasive pest originating from the New World, was accidentally introduced to Nigeria in 2016 (Goergen et al., 2016). In May 2018, it reached southern India (Shylesha et al., 2018) and was reported from Nepal in May 2019 (Bajracharya et al., 2019). It is a polyphagous pest, but maize is its preferred host. Management options vary depending upon the policies, economy, geographical location, and climatic conditions of the countries. In the U.S.A., the use of GMO maize is the major tactic adopted; in Brazil, the use of GMO and augmentative biological control; and in Central America, augmentative and conservation biological control. In the newly invaded continents, there has been a scramble to identify methods that are effective, economical, politically and socially acceptable, and safe to humans, natural enemies, wildlife, and the environment. A survey for locally recruited natural enemies of FAW in Africa and Asia was one of the aspects recognized as important for possible utilization of the agents identified, screened, and proved effective

for augmentative biological control.

An inventory of the parasitoids and predators recorded on FAW in the Americas was prepared by Molina-Ochoa et al. (2007). In India, Shylesha et al. (2018) reported *Telenomus* sp. (Hymenoptera: Platygasteridae) and *Trichogramma* sp. (Hymenoptera: Trichogrammatidae) as egg parasitoids of FAW; *Glyotapanteles creatonoti* (Hymenoptera: Braconidae), *Campoletis chloridaeeae* (Hymenoptera: Ichneumonidae) and an unidentified ichneumonid wasp on FAW larvae; a predator, *Forficula* sp. (Dermaptera: Forficulidae); and an entomopathogenic fungus *Metarhizium (Nomuraea) rileyi*. Sisay et al. (2019) identified the egg-larval parasitoid *Chelonus curvimaclulatus* (Hymenoptera: Braconidae) in Kenya; and *Cotesia icipe* (Hymenoptera: Braconidae) and *Palexorista zonata* (Diptera: Tachinidae) in Ethiopia and Kenya; *Charops alter* (Hymenoptera: Ichneumonidae) in Kenya and Tanzania; and *Coccygidium luteum* (Hymenoptera: Braconidae) in Ethiopia, Kenya, and Tanzania on FAW larvae. Amadou et al. (2018) recorded

*Trichogrammatoidea* sp., *Trichogramma* sp. and *Telenomus* sp. on FAW eggs; and *Chelonus* sp., *Charops* sp., *Cotesia* sp., and an unidentified ichneumonid and a tachinid on FAW larvae. The occurrence of the egg parasitoid *Telenomus remus* in Benin, Cote d'Ivoire, Kenya, Niger, and South Africa was reported by Kenis et al. (2019). Tefera et al. (2019) reported occurrence of *Trichogramma chilonis* in Kenya and prepared a guide of mass production of *T. chilonis* and *T. remus*. The present study reports the occurrence of native egg parasitoids *Trichogramma mwanzai* and *Telenomus remus* in Tanzania and *Trichogramma chilonis* and *Telenomus remus* in Nepal. Efforts to mass culture these parasitoids for augmentative releases in Kenya, Tanzania, and Nepal are discussed.

#### MATERIALS AND METHODS

In August 2019, surveys were conducted in maize fields at Dakawa in Morogoro region (S6.4497272, E37.5334335) in Tanzania for egg parasitoids of FAW by collecting eggs of this pest and incubating them in the laboratory at Kibaha inn Coast Region. Similarly, surveys were carried out in maize fields in Sindhuli, Nepal (N27°25.133', E85°51.758') for egg parasitoids of FAW and collected eggs were incubated in the laboratory at Kathmandu, Nepal. Some specimens were preserved in alcohol for identification by specialists and others used for multiplication. The eggs of the factitious host, *Corcyra cephalonica* (Lepidoptera: Pyralidae), were used for multiplication of *Trichogramma* sp. and eggs of FAW for multiplication of *Telenomus* sp. The morphological and molecular confirmations were made by Gregory Evans and Jason Mottern, respectively.

For the molecular analysis, DNA was non-destructively extracted from four *Trichogramma* specimens (IMDx0455, 0456, 0457, and 0549) and one *Telenomus* specimen (IMDx0548). A fragment of the mitochondrial cytochrome oxidase subunit I (*COI*) was amplified and sequenced for all specimens (GenBank: MT219446, MT219447, MT219448, MT219449, and MT219450). A 593-bp fragment of the large subunit 28S rDNA expansion region *D2* was also amplified for some of the *Trichogramma* specimens (GenBank: MT199195, MT199196, and MT199197). All primer sequences and protocols for DNA extraction, amplification, purification, and sequencing are after Liu and Mottern (2017). Sequences were verified by comparing forward and reverse reads, and mitochondrial DNA was examined for stop codons using the software package Geneious Prime v2019.1.3 (Biomatters- <http://www.geneious.com/>).

Molecular work was conducted at the Insect Molecular Diagnostics Laboratory in Beltsville, MD, USA.

#### RESULTS AND DISCUSSION

Amongst the egg parasitoids obtained from surveys, *Trichogramma mwanzai* Schulten and Feijen is native to Malawi and Kenya (Feijen and Schulten, 1981; Guang and Oloo, 1990) and was introduced from Kenya to India in 2004 for control of *Helicoverpa armigera* (Hübner) (Jalali, 2013). In the molecular analysis, the sequence of the gene 28S-D2 and mtCOI barcode of specimens reared from FAW in Tanzania matched 99.37% to *T. mwanzai* in NCBI GenBank and 100% to some *T. mwanzai* sequences on BOLD. In Tanzania, *T. mwanzai* culture maintained in the laboratory gave about 70% parasitism of FAW eggs, indicating that it is an acceptable candidate for mass culture and augmentative field release for control of FAW. Haile et al. (2002) and Kalyebi et al. (2005) had recommended it for augmentative biological control of *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) and *H. armigera* in maize.

*Trichogramma chilonis* Ishii obtained from the study is native to southern Asia. In the surveys, it was observed parasitizing FAW eggs in Nepal. The specimens collected in Nepal were 99-100% identical to multiple specimens in GenBank. Its introduction to Kenya is not known but it has been collected from FAW eggs in the country (Tefera et al., 2019). Currently, *T. chilonis* is being reared on *Corcyra cephalonica* Stainton eggs for eventual augmentative biological control of FAW in Kenya and Nepal.

*Telenomus remus* Nixon is an egg parasitoid introduced to India from Papua New Guinea in 1963 (Sankaran, 1974). From India, it has been distributed to several countries in Asia and the Caribbean (Cave, 2000) and it is possible that it was fortuitously introduced to Nepal. *Telenomus remus* is known to have existed in Kenya long before FAW arrived in that country, since specimens found in the collection were collected in 1988 (Kenis et al., 2018). Based on the mtCOI barcoding gene, specimens collected in Nepal were observed to be 99.82% identical to multiple specimens in the GenBank.

Among the biological control agents, *Trichogramma* and *Telenomus* are widely distributed in Africa, naturally suppressing FAW populations. Naturally occurring populations of these two biological control agents are meagre but can be augmented by mass

releases of laboratory-reared populations to attain rapid control of the FAW. A strategy to implement biocontrol of FAW calls for public-private partnerships, which includes research centers, private sectors, universities, and extension agents. Designing trainings for national researchers, development agents, and technicians to gain practical hands-on experiences in field collection, mass rearing, and mass release of indigenous/ naturalized biological control agents of the FAW, including egg and larval parasitoids, is important. To harness the full potential of the biological control agents, establishing mass rearing facilities for the biological control agents is critical. These facilities will have a significant impact on research focused on managing FAW. The rearing facility will also support national and international research projects aimed at biological control that can be incorporated in IPM. The IPM Innovation Lab designed a strategy on establishing satellite labs for mass rearing and releases of the biological control agents in Kenya, Nepal and Tanzania and this should be further strengthened by engaging more partners and resources (Hendery, 2020).

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