



# High Parasitism of *Telenomus* and *Trichogramma* Species on *Spodoptera frugiperda* Eggs During Maize Vegetative Stage in Gorontalo, Indonesia

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## Abstract

The fall armyworm (*Spodoptera frugiperda*, Lepidoptera: Noctuidae) is an invasive pest that threatens maize production in Indonesia, particularly during the vegetative stage. This study aimed to identify egg parasitoid species and assess their parasitism levels on *S. frugiperda* during this critical growth phase in Gorontalo, Indonesia. Field sampling was conducted from February to April 2021 using random sampling of egg masses at three maize fields in Suwawa District. The collected eggs were incubated in the laboratory to observe emergence and identify parasitoids. This study revealed the significant contribution of egg parasitoids—particularly *Telenomus* sp.—in suppressing *S. frugiperda* populations during the vegetative stage of maize in Gorontalo, Indonesia. Parasitism rates were remarkably high across all observation periods, ranging from 83.82% to 92.54%, and the emergence of *Telenomus* sp. consistently exceeded that of *Trichogramma* sp. These findings demonstrate that native egg parasitoids are already actively controlling *S. frugiperda* in the field and should be preserved through ecologically sensitive pest management. Avoiding insecticide use during early maize growth stages is essential to maintaining the activity of beneficial parasitoids.

Keywords: Dominance, egg parasitoid, fall armyworm, native, Suwawa district

## Introduction

Fall armyworm (*Spodoptera frugiperda*, Lepidoptera: Noctuidae) is a highly polyphagous pest native to tropical and subtropical regions of the American continent (Sartiami, 2020). This invasive species feeds on more than 353 plant species across 76 families, posing a serious threat to global agriculture (Shaurub, 2024). In recent years, *S. frugiperda* has emerged as one of the most destructive invasive pests worldwide, particularly affecting maize crops (Al-Zyoud et al., 2023). The first reported outbreak in Indonesia occurred in 2019 in West Pasaman,

West Sumatra Province, and rapidly spread across the archipelago (Nonci et al., 2019; Trisyono et al., 2019). As a result, significant economic losses were reported, with national maize yields declining in affected regions (Purnawan, 2020). In Africa, *S. frugiperda* infestations were estimated to cause losses of USD 2.5 to 6.3 billion in 2017 alone (Overton, 2021).

Globally, control of *S. frugiperda* has primarily relied on chemical insecticides. However, this approach has led to widespread resistance, placing *S. frugiperda* among the 15 most resistant arthropod pests globally

(Sparks et al., 2020). Moreover, excessive pesticide use has resulted in environmental contamination, pesticide residues in food, non-target organism mortality, and disruption of natural enemy populations (Arya et al., 2022; Elhamalawy et al., 2024). These drawbacks underscore the urgent need for safer and more sustainable pest control strategies.

Among the environmentally sound alternatives, biological control has gained increasing attention. It involves using natural enemies such as predators, parasitoids, or pathogens, and represents a key component of integrated pest management (IPM) systems (Kenis, 2019). Numerous studies have documented egg and larval parasitoids of *S. frugiperda* globally, including recent discoveries in the Philippines (Calcetas et al., 2023; Pal et al., 2024). In Indonesia, research on local parasitoid complexes is expanding. Several egg parasitoid species with potential for *S. frugiperda* suppression have been reported, including *Telenomus remus* and *Trichogramma* sp. in South Sumatra (Herlinda et al., 2023), *T. remus* and *Microplitis prodeniae* in Bali (Ustriyana et al., 2024), and *Telenomus* sp. and *Mymaridae* sp. in Malang (Rizali et al., 2021). Among these egg parasitoids, species of the genera *Telenomus* and *Trichogramma* have consistently demonstrated high parasitism potential across different regions.

Despite these findings, knowledge regarding the diversity and effectiveness of egg parasitoids in other maize-growing regions remains limited, particularly in Gorontalo Province—an important maize-producing area in Eastern Indonesia. Additionally, many previous studies have focused only on species identification without quantifying parasitism rates, especially during critical crop growth stages such as the vegetative phase. This stage is particularly

important because timely parasitism can prevent larval outbreaks that cause significant crop damage. Therefore, the present study aimed to investigate the species and parasitism levels of egg parasitoids associated with *S. frugiperda* during the vegetative stage of maize in Gorontalo, Indonesia.

## Methods

The research was conducted at Huluduotamo Village, Suwawa District, Bone Bolango Regency, Gorontalo Province, Indonesia and the Plant Pests and Diseases Laboratory at the Faculty of Agriculture, Gorontalo State University. The research was conducted from February to April 2021.

### Method

The study used a survey method in conjunction with a qualitative approach.

### Sampling Area

Samples of *S. frugiperda* egg masses were collected from three distinct locations at the following coordinates: 0°32'49"N, 123°08'48"E; 0°32'48"N, 123°08'57"E; and 0°32'39"N, 123°09'36"E, with altitudes ranging from 78 to 105 meters above sea level (Figure 1).

### Sampling and Incubation of *S. frugiperda* Egg Masses

Sampling of *S. frugiperda* egg masses was conducted at 2, 4, and 6 weeks after planting (WAP), following the findings of Herlinda et al. (2023), which reported that parasitism rates are generally higher during the vegetative stage. All sampling activities were performed exclusively during this vegetative phase.

At each of the three sampling sites, 10 egg clusters were collected using a simple random sampling method. Individual maize plants within a 200 m<sup>2</sup> area were selected at random, without a predetermined pattern or spatial stratification. Leaves containing egg

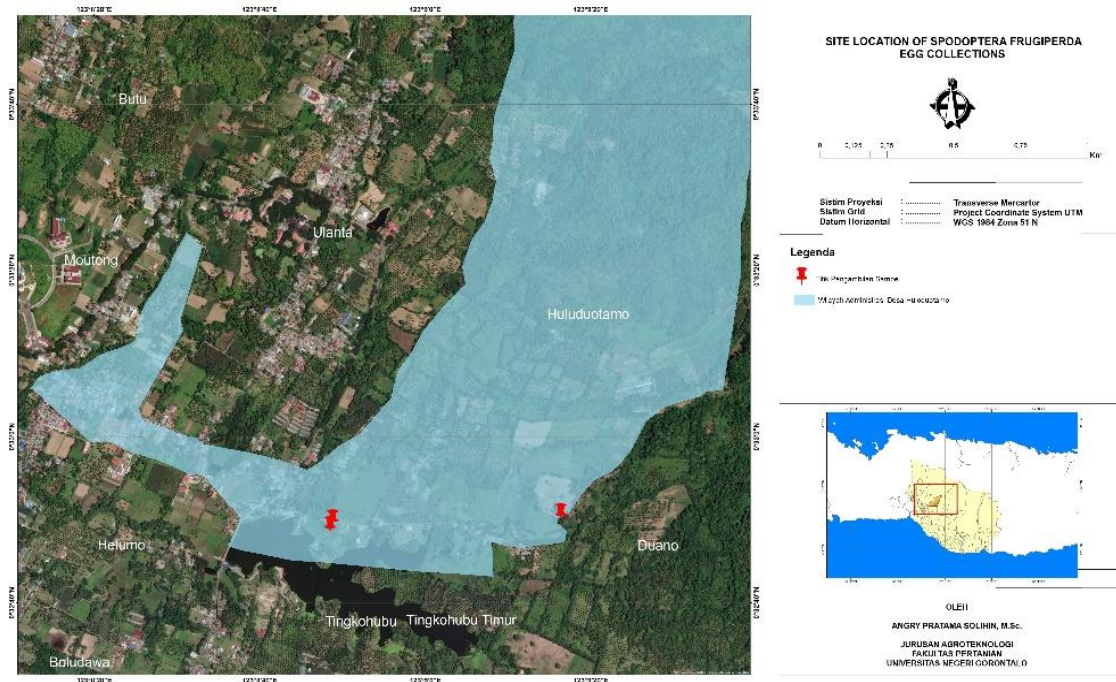


Figure 1. Site location of *Spodoptera frugiperda* eggs collection

masses (approximately 5 cm<sup>2</sup> in size) were clipped using sterilized scissors and placed into sterile plastic containers for transport.

The collected egg clusters were transferred to clean glass bottles (1.5 cm diameter × 8 cm height) lined with tissue paper moistened with 1 mL of sterile water to maintain humidity. The bottles were then covered with chiffon fabric, secured with rubber bands, and properly labeled with site and sample information.

The egg masses were incubated for approximately one week under ambient laboratory conditions. During the incubation period, non-parasitized eggs remained white and eventually hatched into larvae, whereas parasitized eggs gradually darkened and produced adult parasitoids. Emerged parasitoid adults were maintained for 24 hours before being preserved in 70% ethanol-filled microtubes for identification.

### Parasitism Level

Prior to assessing parasitism levels, the total number of individual eggs within each *S.*

*frugiperda* egg mass was counted under a binocular microscope (Leica DM1000) at 10× magnification. Daily observations were conducted throughout the incubation period until all eggs had either hatched into larvae or became adults. The parasitism level was calculated using the following formula:

$$P = \frac{n}{N} \times 100\% \dots\dots\dots (1)$$

Where: *P* = Parasitism level, *n* = number of parasitized eggs (eggs that produced parasitoid adults), *N* = total number of eggs observed.

### Identification of Egg Parasitoids

Adult parasitoids emerging from the incubated egg masses were identified morphologically using standard entomological keys and taxonomic references. Identification followed the procedure described by Nurkomar et al. (2024), with confirmation based on diagnostic morphological features using Borror and White (1970), Goulet and Huber (1993), Tobing et al. (2023), Karundeng et al. (2024). Key morphological characteristics such as body color, wing

venation, antennal structure, and body size were used to distinguish between *Telenomus* sp. and *Trichogramma* sp.

### Emerged Parasitoids

The number of individual parasitoids that emerged from each egg cluster was recorded daily. Each adult was identified to genus level, and the total number of individuals per species was documented to assess the relative abundance and dominance of *Telenomus* sp. versus *Trichogramma* sp. across the sampling periods.

## Results

### Parasitism Level

The average parasitism rate of *Spodoptera frugiperda* egg parasitoids was consistently high across all observation periods during the maize vegetative stage (Figure 2). The highest parasitism rate was observed at 2 weeks after planting (WAP), reaching 92.54%. This value declined slightly to 83.82% at 4 WAP, before increasing again to 92.43% at 6 WAP.

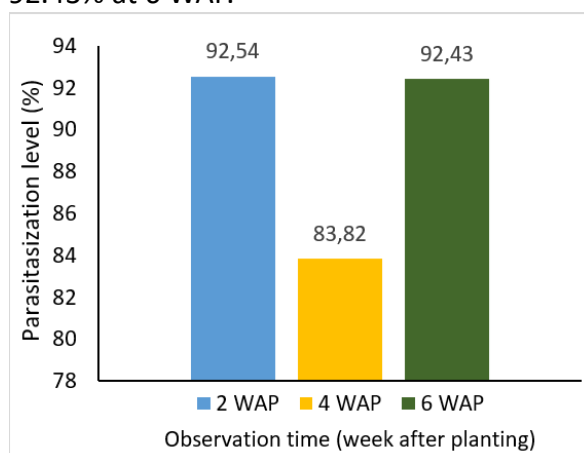


Figure 2. Parasitism level of *Spodoptera frugiperda* egg parasitoid

### Egg Parasitoid Species

Two species of egg parasitoids were identified from the collected *S. frugiperda* egg masses: *Telenomus* sp. (Hymenoptera: Platygasteridae) and *Trichogramma* sp. (Hymenoptera: Trichogrammatidae). The

majority of egg clusters were parasitized by *Telenomus* sp. alone; however, a smaller proportion showed parasitism by species.

The two parasitoid genera exhibited distinct morphological characteristics that facilitated their identification. *Telenomus* sp. adults were metallic black, with a body length of approximately 1–2 mm. The antennae were elbowed and oriented downward, with clubbed segments consisting of 9–10 flagellomeres. The species possessed two pairs of wings, with transparent forewings being larger than the hindwings, and tibiae bearing paired distal spines (Figure 3).

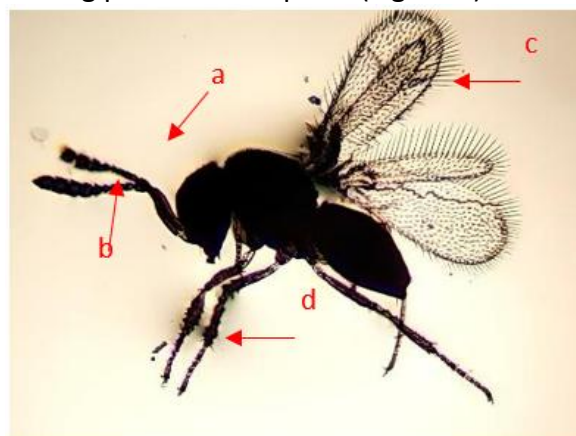
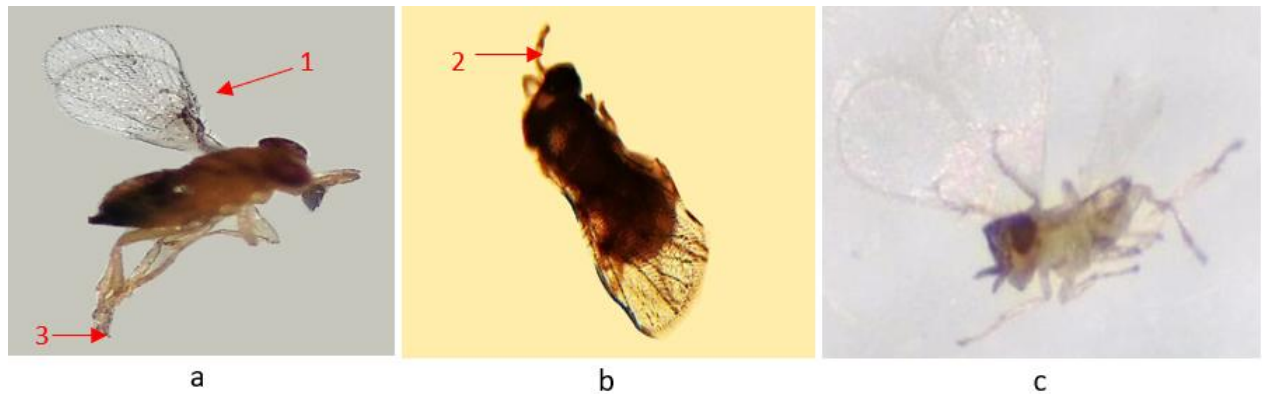


Figure 3. Morphology of *Telenomus* sp.: a. Basal segments of the antenna, inserted at the lower part of the head (geniculate), b. Distal segmented portion of the antenna, usually consisting of 9–10 flagellomeres with a clubbed (clavate), c. Wing covered with fine setae and simple venation, d. Tibia bears apical spines

*Trichogramma* sp. adults were significantly smaller (less than 1 mm), with a soft-bodied structure and yellow-orange coloration. Forewings were broader and more rounded than the hindwings, and both pairs of wings were covered in dense setae. The antennae were shorter than the head and mesosoma, and the tarsi consisted of three segments (Figure 4).

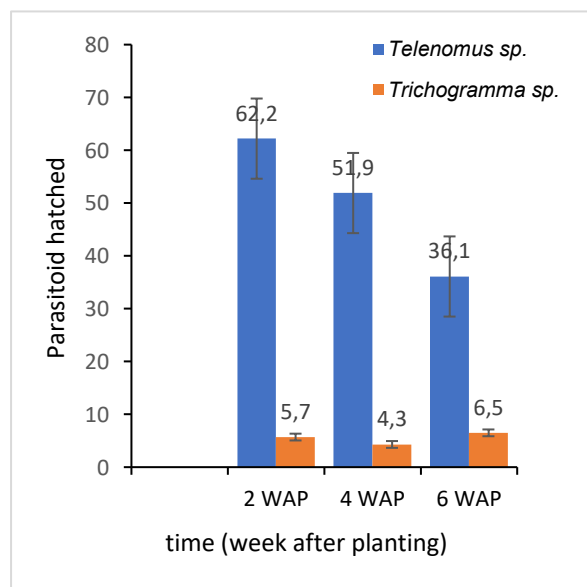


**Figure 4.** Morphological characteristics of *Trichogramma* sp.: (a) lateral view, (b) dorsal view (personal documentation), and (c) adult specimen (adapted from Nurkomar et al., 2024). Key diagnostic features include: 1. Wings covered with dense setae and multiple veins, 2. Antennae shorter than the combined length of the head and mesosoma, 3. Tarsi composed of three segments

### Number of Emerged Parasitoids

The number of individual parasitoids that emerged from *S. frugiperda* egg masses varied across the three maize growth stages observed (2, 4, and 6 weeks after planting). In all sampling periods, *Telenomus* sp. was consistently more abundant than *Trichogramma* sp., indicating its dominance as the primary egg parasitoid in Gorontalo maize ecosystems (Figure 5).

At 2 WAP, the average number of *Telenomus* sp. individuals that emerged per egg mass was 62.2, while *Trichogramma* sp. accounted for 5.7 individuals. At 4 WAP, emergence decreased slightly to 51.9 individuals for *Telenomus* sp. and 4.3 for *Trichogramma* sp. At 6 WAP, the number of *Telenomus* sp. continued to decline to 36.1, whereas *Trichogramma* sp. showed a slight increase to 6.5 individuals.



**Figure 5.** Number of individual egg parasitoid hatched

### Discussion

As one of the most important biological agents in reducing pest populations, egg parasitoids play an essential role in integrated pest management. Providing optimal conditions for *S. frugiperda* egg parasitoids and minimizing the damage caused by this pest is possible. As a result, *S. frugiperda* can be controlled before the active damaging phase (larvae) begins. The parasitization level of *S. frugiperda* eggs was extremely high throughout the observation. This indicates that *S. frugiperda* egg parasitoids play a significant role in suppressing agroecosystem pest populations. This is in line with Masry and El-Wakeil's (2020) research, which concluded that using egg parasitoids is the most effective method

of controlling plant pests and plays an important role in integrated pest management. One of the factors contributing to the high parasitism rate of *S. frugiperda* egg parasitoids is the absence of insecticide application by farmers at the study site. This finding aligns with the research by Turchen et al. (2016) and Araújo et al. (2022), which demonstrated that chemical insecticide applications can reduce the parasitism rate and viability of parasitoids targeting insect pest eggs. The high parasitization level of egg parasitoid indicates that the intervention to control *S. frugiperda* using chemical insecticides in the early vegetative phase of maize is not required. Nevertheless, this would affect the egg parasitoid that plays a vital role in the natural control of *S. frugiperda*.

This study observed fluctuations in the parasitism level of *S. frugiperda* egg parasitoids. These fluctuations may be influenced by several factors, including host population density, host availability, and farming practices such as the use of insecticides. Host population density and availability are critical in determining parasitoid populations and parasitism rate in the field (Godfray and Müller, 1998). During the study, the population of *S. frugiperda* egg clusters at each sampling site was relatively high. Moreover, the use of insecticides significantly affects the population and parasitism level of *S. frugiperda* egg parasitoids (Milonas et al., 2021; Turchen et al., 2016). Interviews with maize field owners revealed that farmers had never applied insecticides to their crops.

*S. frugiperda* pest has been reported in Indonesia since 2019 as an invasive pest from the American continent. There is a concern that this pest cannot be controlled by the natural enemies that originated in Indonesia. According to this study, the parasitoids that

attack *S. frugiperda* eggs are *Telenomus* sp. and *Trichogramma* sp. These parasitoids are commonly identified as egg parasitoids that target the eggs of various insect pests, including *Spodoptera* sp. (Liao et al., 2019; Ning et al., 2023). The findings in this study are in line with (Oktaviani et al., 2022; Sari et al., 2021), which stated that these two parasitoids (*Telenomus* sp. and *Trichogramma* sp.) were predominantly found parasitizing *S. frugiperda* eggs in Indonesia. In addition, these two egg parasitoids are reported to be the most effective biological agents in controlling *S. frugiperda* and other major pests (Abbas et al., 2022). Both parasitoids are well established in Indonesia and significantly control pest populations, particularly those of the Lepidoptera. These findings confirm the existence of an association between *S. frugiperda* and local egg parasitoids in Indonesia (Nurkomar et al., 2024).

Parasitoid composition in agroecosystems plays a significant role in determining their impact on pest control. A parasitoid's role in suppressing pest populations becomes more important and dominant. According to this study, *Telenomus* sp. has played a dominant role over *Trichogramma* sp. The results of this study were confirmed (Wahyuningsih et al., 2022, and Navik et al., 2023) that the parasitization level of *Telenomus* sp. is more dominant than that of *Trichogramma* sp. The dominance of *Telenomus* sp. is closely related to its sensitivity to the scales that cover the *S. frugiperda* egg masses in the host searching process (Li et al., 2023). In addition, *Telenomus* sp. is quicker at locating and parasitizing *S. frugiperda* eggs than *Trichogramma* sp. This rapid ovipositing behavior allows *Telenomus* sp. to exploit a larger number of eggs in a shorter timeframe, thereby increasing its overall parasitism rates and reducing the likelihood of superparasitism

by *Trichogramma* sp. (Laminou et al., 2020). Furthermore, the structural arrangement of *S. frugiperda* egg masses poses challenges for *Trichogramma* spp., which are smaller and can only access eggs on the periphery of these masses. This limitation results in lower parasitism rates for *Trichogramma* compared to *Telenomus*, which can penetrate deeper into the egg mass (Fortes et al., 2023).

## Conclusion

This study revealed the significant contribution of egg parasitoids—particularly *Telenomus* sp.—in suppressing *S. frugiperda* populations during the vegetative stage of maize in Gorontalo, Indonesia. Parasitism rates were remarkably high across all observation periods, ranging from 83.82% to 92.54%, and the emergence of *Telenomus* sp. consistently exceeded that of *Trichogramma* sp. These findings demonstrate that native egg parasitoids are already actively controlling *S. frugiperda* in the field and should be preserved through ecologically sensitive pest management. Avoiding insecticide use during early maize growth stages is essential to maintaining the activity of beneficial parasitoids.

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## Declaration

### Author contribution

Angry Pratama Solihin is the main contributor and correspondence author. Silvany Suwatan and Indriati Husain are co-authors. All authors read and approved the final paper.

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### Competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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