The potential of *Telenomus remus* Nixon (Hymenoptera: Scelinoidae) as Biocontrol Agent for the New Fall Armyworm S. frugiperda (Lepidoptera: Noctuidae) in Indonesia

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ABSTRACT

The fall armyworm Spodoptera frugiperda is an emerging new pest species in several Asian countries including Indonesia. This pest can be a threat to Indonesian agriculture because this pest has been reported to cause many losses in other countries. As a preemptive and ecofriendly control strategy, a research to study the performance of Telenomus remus as potential biocontrol agent of this pest was done in laboratory scale. Research was done by exposing an adult female to 50 eggs of S. frugiperda in a cluster. We also exposed the female parasitoid to another 50 eggs of S. litura in a cluster for comparison since this parasitoid had been reported as S. litura egg parasitoid in Indonesia previously. Results showed that there are no difference in the numbers of parasitized eggs, parasitism rate, survival rates and percent females of T. remus reared from both S. frugiperda and S litura, which implies the effectiveness of T. remus as a candidate for biocontrol agent for S. frugiperda.

Keywords: Biological control, Parasitoid, Spodoptera frugiperda, Telenomus remus

ABSTRAK

Ulat grayak *Spodoptera frugiperda* merupakan hama baru di beberapa negara Asia termasuk Indonesia. Ulat grayak dapat menjadi ancaman bagi pertanian di Indonesia karena hama ini telah dilaporkan dapat menimbulkan kehilangan hasil dalam jumlah banyak di negara-negara lain. Sebagai tindakan pengendalian preemptive yang bersifat ramah lingkungan, sebuah penelitian dengan tujuan mempelajari kemampuan *Telenomus remus* sebagai agen hayati potensial bagi *S. frugiperda* telah dilakukan pada skala laboratorium. Penelitian dilakukan dengan cara memaparkan satu *T. remus* betina dewasa terhadap 50 telur *S. frugiperda*. *T. remus* juga dipaparkan terhadap 50 telur *S. litura* sebagai perbandingan. *S. litura* dipilih karena *T. remus* telah dilaporkan efektif dalam mengendalikan *S. litura*. Hasil penelitian menunjukkan bahwa jumlah telur yang diparasit, tingkat parasitisme, kemampuan bertahan hidup dan jumlah keturunan betina *T. remus* yang dihasilkan baik dari inang *S. frugiperda* maupun *S. litura* tidak berbeda. Dengan demikian, parasitoid telur *T. remus* dapat digunakan sebagai agen hayati potensial bagi *S. frugiperda*.

Kata Kunci: Pengendalian hayati, Parasitoid, *Spodoptera frugiperda, Telenomus remus*

INTRODUCTION

Spodoptera spp. (Lepidoptera: Noctuidae) are the common pest of Indonesia including *Spodoptera litura* and *S. exigua* (Kalshoven, 1981). *Spodoptera litura* is the most voracious among the genus of *Spodopotera* which is commonly found in leguminous plants (Tengkano & Suharsono, 2005) and *S. exigua* is commonly found in onion and other 170 plant species (Zhang, Huai, Helen, & Wang, 2011). In the meantime, *Spodoptera frugiperda* is a newly reported pest species of Indonesia in 2019. This pest was found around Sumatera, Java, and Kalimantan island (BBPOPT, 2019). This pest was found attacking corn in a low population in Java (Maharani et al., 2019). In contrast, Trisyono, Suputa, Aryuwandari, Hartaman, and Jumari (2019) reported the 100% infestation level of *S. frugiperda* in Lampung.. This pest can also attack another crop such as soybean, cotton, rice and other grasses, and weeds (Nabity, Zangerl, Berenbaum, & DeLucia, 2011; Pogue, 2002). *S. frugiperda* originates from America (Sparks, 1979) and widespread to Africa in 2016 (Goergen, Kumar, Sankung, Togola, &

Tamò, 2016) threatened corn yield loss of 8.3 to 20.6 million tons per annum ((Day et al., 2017). In 2018, this pest was reported from China with a quick distribution rate of up to 17 provinces in a month (Jiang, Liu, & Zhu, 2019). *S. frugiperda* was also reported in India, Bangladesh, Thailand, Myanmar, and Sri Lanka in 2018 (CABI, 2019a).

Maharani et al. (2019) stated that the low infestation level of *S. frugiperda* in Indonesia is followed by the presence of natural enemies such as parasitoid and entomopathogenic pathogens in the field with unclear parasitism rate. The presence of natural enemies in the field is an insight for possible natural control taken in the future. One possibility for controlling *S. frugiperda* is the use of natural enemies that is egg parasitoid *Telenomus remus* Nixon (Hymenoptera: Scelionidae) (Kenis et al., 2019).

Telenomus remus is an egg parasitoid of various lepidopteran pest species including genus *Spodoptera* (CABI, 2019b). Buchori, Herawati, and Sari (2017) reported that the release of *T. remus* able to suppress 48% population of *S. exigua* in potted onion plants. Meanwhile, Satyanarayana, Ballal, and Rao (2005) reported 96% parasitism rate of *S. litura* eggs by *T. remus*. Furthermore, Liao et al. (2019) showed that field parasitism incidence of *S. frugiperda* by *T. remus* in the field in China can reach up to 60.19%. Biecological key aspects of parasitoid is an important factor in determining parasitoid performance in controlling a pest in the field (Waage & Hassell, 1982). However, no study reports the bioecological key aspect of *T. remus* in *S. frugiperda*. In this research, we study the performance of *T. remus* on *S. frugiperda* and compare it to *S. litura* under laboratory conditions. This is a preemptive control strategy that can be used for natural and sustainable control of *S. frugiperda* using parasitoid in the future.

MATERIALS AND METHODS

Insect mass rearing

Both *S. litura* and *S. frugiperda* larvae were collected from a corn field in Dramaga, Bogor, Indonesia. Both larvae were taken to the laboratory for further observation. To avoid cannibalism among the larvae, each larva was reared separately in a divided plastic container. Larvae were fed using baby corn which is replaced every two days. The last instar larvae were transferred to a plastic container (35 x 28 x 7 cm) containing sterilized sand as a media for pupation. The pupae were placed in a cylindrical plastic cage (d = 15 cm, h = 10 cm) until the emergence of the moth. The moths were reared in the similar cage for pupation. The moths were fed using a 20 % honey solution.

Meanwhile, collected parasitized larvae of *S. frugiperda* were reared in a 50 ml test tube containing honey droplets as a food source until the emergence of the adult. Two days after emergence, a mated female of *T. remus* was introduced to a petri dish (86 x 13 mm) containing *S. frugiperda* egg cluster. Parasitized *S. frugiperda* larvae were reared using the same method for rearing unparasitized larvae until the formation of *T. remus* pupae. These new emerging parasitoids were used for the experiment.

The performance of *T. remus* on *S. frugiperda*

The performance of *T. remus* on *S. frugiperda* was tested by exposing a mated female to one egg mass consisting of 50 eggs of *S. frugiperda* for 24 h in a 250 ml test tube. Honey droplets were provided as an additional food source. After the test, parasitized eggs were reared until the emergence of the new parasitoids by the similar method for rearing the parasitoid. The test was repeated ten times using different females. Parameter tested including the number of parasitized eggs, parasitism rate, number of emerging parasitoids, survival rate and sex ratio (percent females). These parameters are determined based on the method of Puspitaningtyas, Nurkomar, and Buchori (2019). We used this similar procedure to test the subject on *S. litura* for comparison.

Statistical Analysis

To compare the performance of *T. remus* on *S. frugiperda* and *S. litura*, all data parameters including the number of parasitized eggs, parasitism rate, number of emerging parasitoids, survival rate and sex ratio (percent females) was subjected to two-paired t-test analysis using R-statistic version 3.5.2 (RCoreTeam, 2013).

RESULTS AND DISCUSSIONS

The presence of *S. frugiperda* as a new pest in several Asian countries including Indonesia is a threat that needs attention. The presence of a new pest into a new area can cause attacks at high or low levels. An insect species can cause high attack so that it becomes the major pest in a plant, but also can be a minor pest in other plants. A pest can also be a major pest in one area but can also only be a minor pest in another area (Hill, 2008). In this case, *S. frugiperda* attack has threatened corn production in Africa. However, *S. frugiperda* attack reported has the potential to reduce corn production in Indonesia. In other words, the status of this pest is classified as a minor pest since the infestation level is still low (1 larva per plant) (Trisyono et al., 2019). Pereira and Lee Hellman (1993) concluded that the economic injury level for *Spodoptera* is two larva per plant in Maryland. One of the factors that cause pests to become minor pests is due to the role of natural enemies that are able to control the pest population (I Nurkomar, Manuwoto, Kainoh, & Buchori, 2018). *Telenomus remus* is a natural enemy that can be used as a natural enemy of some lepidopteran eggs (CABI, 2019b). Liao et al. (2019) reported 60.19% field parasitism rate of *S. frugiperda* by *T. remus*.. So far, *T. remus* has been reported to be used as a biological control agent of *S. litura* (Susiawan & Yuliarti, 2017) and *S. exigua* (Buchori et al., 2017), another armyworm pest species that have long been existed in Indonesia (Kalshoven, 1981). In this study, we compare the performance of *T. remus* in parasiting *S. frugiperda* and *S. litura* under laboratory conditions.

The result showed that no differences in the performance of *T. remus* either on *S. frugiperda* or *S. litura* as host. *T. remus* successfully parasitized 69.40% (35/50) eggs of *S. frugiperda* and 80.80% (40/50) eggs of *S. litura* (Paired t-test, P=0.137,

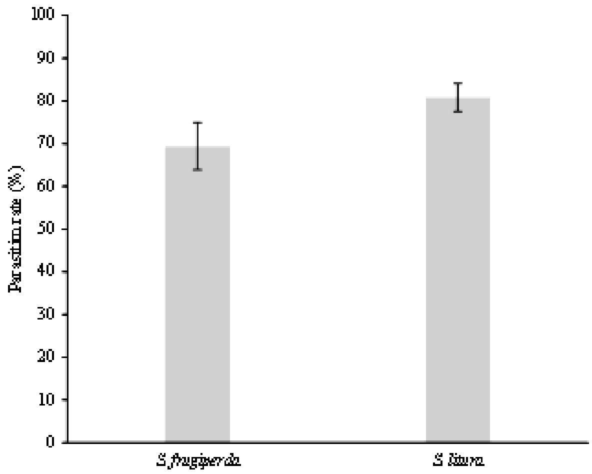

Figure 1. Parasitism rate of *S. frugiperda* and *S. litura* by *Telenomus remus*

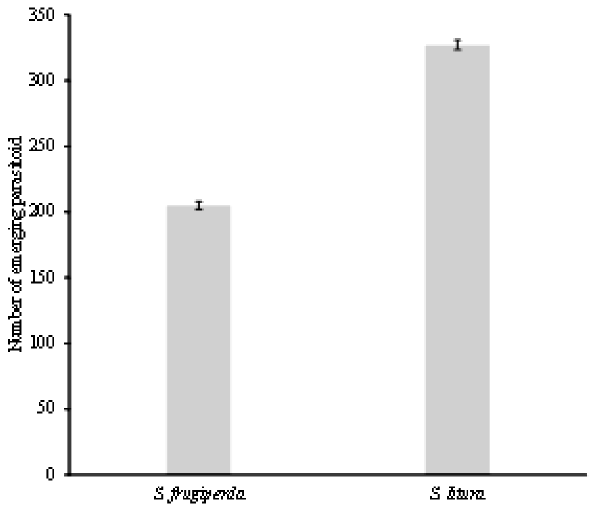

Figure 2. Number of emerging parasitoids reared on *Spodoptera frugiperda* and *S. Litura*

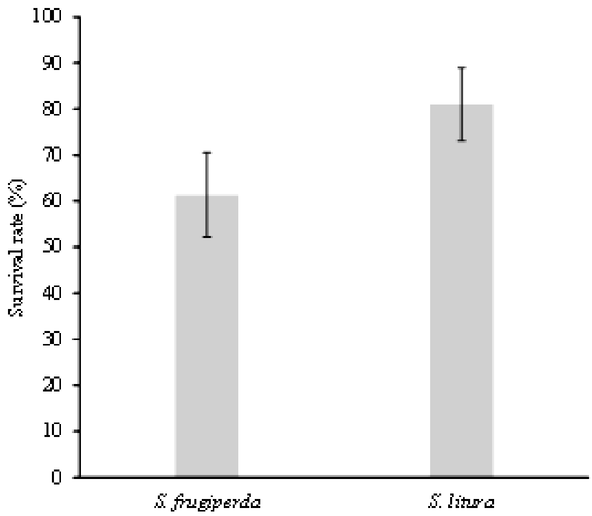

Figure 3. Survival rate of *Telenomus remus* reared on *Spodoptera frugiperda* and *S. litura*

n=10) (Figure 1). However, there is a significant difference in the number of emerging parasitoids (Paired t-test, P=0.048, n=10) (Figure 2). Parasitoid produced from *S. litura* eggs 63% more than those from *S. frugiperda*. *T. remus* showed high survival rate reared both of host (Paired t-test, P=0.07, n=10) (Figure 3). Furthermore, both of host able to produce more than 50% females (Figure 4).

The results showed that there were no differences in the performance of *T. remus* in the two hosts tested. This shows that *T. remus* can be used as a natural enemy for *S. frugiperda* (Figure 5).

Other potential natural enemies for *S. frugiperda* is larval parasitoid *Coccygidium melleum* (Hymenoptera: Braconidae), *Campoletis chlorideae* (Hymenoptera: Ichneumonidae), *Eriborus* sp. (Hymenoptera: Ichneumonidae), *Odontepyris* sp. (Hymenoptera: Bethylidae), *Exorista sorbillans* (Diptera: Tachinidae); *Forficula* sp. (Dermaptera: forficulidae); predatory beetle *Harmonia octomaculata* (Coleoptera: Coccinellidae), *Coccinella transversalis* (Coleoptera: Coccinellidae), and Entomopathogenic fungi *Nomuraea rileyi* (Kalleshwaraswamy, Poorani, Maruthi, Pavithra, & Diraviam, 2019).

No performance differences were shown for all parameters tested except for the number of emerging parasitoids. *T. remus* that is reared in *S. litura* produced more parasitoids than that of reared in *S. frugiperda* as host. This because the number of parasitized *S. litura* eggs is higher than the number of *S. frugiperda* eggs. In addition, *T. remus* showed no difference survival rate in both of host. Our result suggests that *T. remus* can be used as a natural enemy for controlling *S. frugiperda*. However, several factors need to be considered in utilizing a parasitoid as a biocontrol agent such as host selection behavior (Zuim et al., 2017). Host age must be considered for utilization of *T. remus* for controlling *S. frugiperda* since the number of *S. frugiperda* eggs parasitized by *T. remus* decreases with increasing age of the host egg (de Queiroz et al., 2019). In another study, it was also reported that the older the host age, the smaller the number of parasitized host, i.e., the number of eggs of *Botesia botrana* parasitized by *Trichogramma cacoeciae* is greater at the age of 1 or 2 days than that of 3 or 4 days old (Pizzol, Desneux,

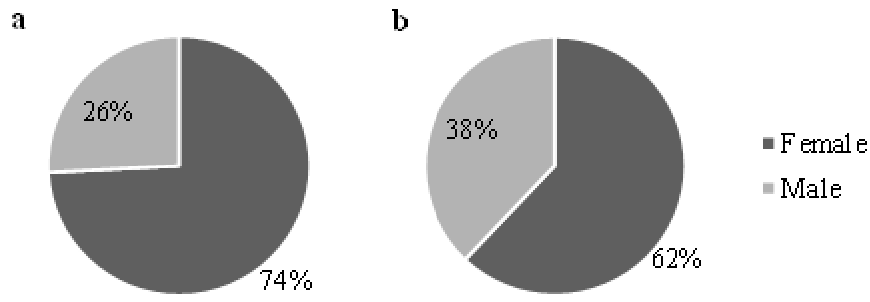

Figure 4. Sex ratio of *Telenomus remus* reared on *S. frugiperda* (a) and *S. litura* (b)

Figure 5. *Telenomus remus* parasitizing *Spodoptera frugiperda*'s egg cluster

Wajnberg, & Thiéry, 2012). However, there are also parasitoids that do not differentiate host age in the parasitization process, i.e., *Trichogramma chilonis* does not show differences in the level of parasitism at the different age of the host *Cytotella cytella* (Zahid, Farid, Sattar, & Khan, 2007).

In this study, *T. remus* was exposed to 50 eggs both of *S. litura* and *S. frugiperda*. The number of parasitized eggs is 34.7 and 40.4 for *S. frugiperda* and *S. litura* respectively. This is in line with the research of (Carneiro, Fernandes, Cruz, & Bueno, 2010) who tested the functional response of *S. frugiperda* with different exposure times that on the number of host eggs by 50 eggs, the number of parasitized eggs was 20-30 eggs. In general, *T. remus* has a type II functional response in which the more the number of hosts is given, the number of parasitized hosts is increasing. The number of parasitic eggs does not increase at a certain host density (150 - 300) eggs exposed.

CONCLUSION

Our finding concluded that *T. remus* as a larval parasitoid of common armyworm *S. litura* can be used as potential biocontrol agent for controlling *S. frugiperda*, a new invasive pest species in several countries including Indonesia.

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