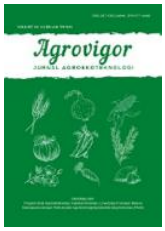
Open Access & Available Online

Agrovigor: Jurnal Agroekoteknologi
ISSN: 1979-5777 (*Print*), 2477-0353 (*Online*)

Journal homepage: https://journal.trunojoyo.ac.id/agrovigor



Article

Parasitization, Parasitism, and Comparison of Sex Ratio of *Telenomus remus* to Eggs of *Spodoptera frugiperda* on Maize Plants in Kulon Progo Regency

Chiquita Almira[1], Ichsan Luqmana Indra Putra[2*]

[1]Biology Study Program, Faculty of Applied Sciences, Universitas Ahmad Dahlan, Yogyakarta 55191, Special Region of Yogyakarta, Indonesia.
[2]Laboratory of Ecology and Systematics, Biology Study Program, Faculty of Applied Sciences, Universitas Ahmad Dahlan, Yogyakarta 55191, Special Region of Yogyakarta, Indonesia.

*Corresponding author: **Ichsan Luqmana Indra Putra (ichsan.luqmana@bio.uad.ac.id)**

ARTICLE INFO

Article history
Received: June 2026
Accepted: September 2026
Published: September 2026

Keywords
Kulon Progo;
Parasitism level;
Parasitization rate;
Sex ratio;
Telenomus remus;

DOI:
https://doi.org/10.21107/agrovigor.v19i2.33082

Copyright:
© 2026 by the authors.
Licensee Agrovigor: Jurnal Agroekoteknologi.
This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution-Share Alike 4.0 (CC BY SA) license (https://creativecommons.org/licenses/by-sa/4.0/).

ABSTRACT

Spodoptera frugiperda is an invasive pest that causes severe damage to maize crops in Kulon Progo Regency. One biological control effort against this pest is the use of the egg parasitoid *Telenomus remus*. This study aimed to analyze the parasitization rate, parasitism rate, sex ratio, and their correlations in *T. remus* parasitizing *S. frugiperda* eggs in maize fields in Kulon Progo Regency. Egg samples were collected from maize fields using a W-pattern scouting method and reared under laboratory conditions until adult parasitoids or host larvae emerged. The number of parasitized eggs, successful parasitoid emergence, and the proportion of female and male individuals were recorded. The results showed that *T. remus* exhibited a relatively high parasitization rate, while the parasitism rate was moderate, with a female-biased sex ratio. Correlation analysis indicated that parasitization rate, parasitism rate, and sex ratio were not significantly correlated. These findings indicate that the developmental success of *T. remus* is influenced more by the biological condition of host eggs than by the number of eggs parasitized.

INTRODUCTION

Parasitoids are organisms that spend part of their life cycle as larvae inside the host's body, eventually causing the host's death (Muliani & Srimurni, 2022). This process is known as parasitism, in which parasitoids use the host as a breeding ground (Mercer, 2020). According to Purba et al. (2023), parasitism occurs when one organism lives on or within another organism and exploits its resources, thereby causing disturbance or harm to the host. One parasitoid that plays an important role in agricultural ecosystems is *Telenomus remus* (Hymenoptera: Scelionidae), which plays a role in the biological control of pests from the Noctuidae family, especially *Spodoptera frugiperda* (J.E. Smith) or the fall armyworm. This pest is one of the main organisms that disrupt corn crops and various other important commodities around the world (Kenis et al., 2019). Parasitisation by *T. remus* prevents *S. frugiperda* eggs from hatching into larvae (Sari et al., 2020), thereby significantly suppressing pest populations (Lacerda et al., 2023). The success of *T. remus* as a biological control agent is due to its ability to penetrate and attack eggs throughout the entire egg mass, including the deepest parts that are difficult for other parasitoids to reach. One of the distinctive characteristics of *T. remus* is the well-developed ovipositor in females, which is used to inject parasitoid eggs into the host eggs as the initial stage of parasitization. In contrast, males possess short and broad genitalia with a concave central plate, which functions in the reproductive process (Oktaviana et al., 2022; Harahap & Siregar, 2024).

Research in various regions shows variations in *T. remus* parasitism on *S. frugiperda* eggs. Laminou et al. (2020) reported a parasitism rate of over 80% in Sadore, Niger. Similar values were found by Oktaviana et al. (2022) in Bogor, West Java (91%), while Mursyidin et al. (2024) on Sumbawa Island recorded a range of 23.54–61.22%. Mass release programmes of *T. remus* in various countries have also shown promising results, with field parasitism rates of 30–90% in Venezuela and Dominica, and high effectiveness in Brazil at a release rate of 600,000 individuals per hectare (Colmenarez et al., 2022). In addition to the parasitism rate, the effectiveness of *T. remus* control is also assessed by its parasitism rate, which is a measure of the success of parasitoids in producing adults from parasitised eggs (Laminou et al., 2020; Qu et al., 2020). Research results show that the parasitism rate of *T. remus* in the laboratory can reach more than 80% (Bueno et al., 2010), while in the field it ranges from 14.74–71.97% (Nurkomar et al., 2024). In addition to parasitism and parasitism, the effectiveness of parasitoids is also influenced by the sex ratio in their population (Hardy, 2002).

The sex ratio is the ratio of males to females (Hossain et al., 2012) that can influence mating behaviour and reproductive success (Stone et al., 2007). The *T. remus* population generally shows a bias towards females (Laminou et al., 2020), and research by Oktaviana et al. (2022) reported a male to female ratio of 1:2.03. A high female ratio contributes to increased parasitism rates because females play a direct role in the oviposition process (Pabbage & Tandiabang, 2007). Control of *S. frugiperda* generally still relies on the use of chemical pesticides such as deltamethrin, which is effective but has the potential to cause negative impacts on the environment and human health (Wulandari et al., 2021). Therefore, biological control strategies are a safer and more sustainable alternative. This approach is able to suppress pest populations naturally and in an environmentally friendly manner, while reducing dependence on synthetic pesticides (Pu'u & Syatrawati, 2022). The presence of *T. remus* parasiting *S. frugiperda* eggs has been widely reported in Indonesia, including in West Java (Sari et al., 2021), West Nusa Tenggara (Mursyidin et al., 2024), North Sumatra (Harahap & Siregar, 2024), and South Sumatra (Herlinda et al., 2023). In the Special Region of Yogyakarta Province, research by Nurkomar et al. (2024) reported the diversity of parasitoids, one of which is *T. remus*, in several areas including Kulon Progo. However, in-depth studies on the effectiveness of *T. remus* in controlling the *S. frugiperda* population in this region have not been widely conducted. Based on this, this study aims to analyse the level of parasitism, parasitism, and the comparison of the sex ratio of *T. remus* to *S. frugiperda* eggs in corn plantations in Kulon Progo Regency. The results of this study are expected to provide scientific information on the natural potential of *T. remus* as a biological control agent for *S. frugiperda*, as well as to serve as a basis for the development of environmentally friendly integrated pest management strategies in the region.

MATERIALS AND METHODS

Materials

The materials used consisted of *S. frugiperda* eggs collected from the field, *T. remus* imagoes hatched from parasitised eggs, 96% alcohol, and 6 × 3 cm paper labels.

Methods

Determination of samling locations

The research location was determined through a survey of 12 subdistricts in Kulon Progo Regency (Figure 1) using Google Earth to map the sampling locations. Three villages were selected using purposive sampling from each subdistrict using a stratified method, and one corn field was purposively selected in each village based on criteria such as the presence of *S. frugiperda* attack symptoms, such as characteristic bite marks and larval faeces on the leaves. Sampling was carried out using a modified 'W' pattern scouting method (Nonci et al., 2019; Nurkomar et al., 2024), with eight observation stations in each field and ten plants observed sequentially at each station. *Spodoptera frugiperda* eggs were collected directly from the leaf surface using the hand-picking technique and then placed in labelled plastic clips according to the collection location.

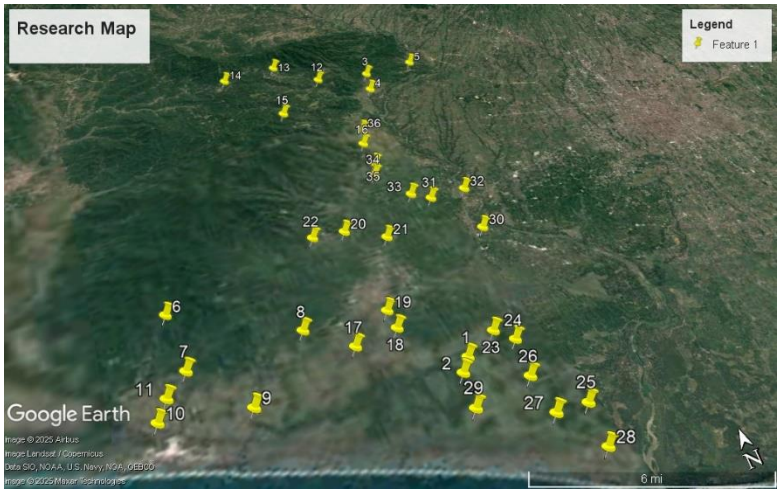


Figure 1. Sampling location in Kulon Progo Regency. 1: Kanoman; 2: Panjatan; 3: Banjarsari; 4: Banjararum; 5: Banjarharjo; 6: Kalirejo; 7: Hargomulyo; 8: Hargorejo; 9: Plumbon; 10: Banjarsari; 11: Hargorejo; 12: Purwoharjo; 13: Gerbosari; 14: Pagerharjo; 15: Purwosari; 16: Giripurwo; 17: Triharjo; 18: Bendungan; 19: Giripeni; 20: Sendangsaro; 21: Pengasih; 22: Karangsari; 23: Bumirejo; 24: Damangrejo; 25: Nomporejo; 26: Wahyuharjo; 27: Karangsewu; 28: Banaran; 29: Bugel; 30: Salamrejo; 31: Banguncipto; 32: Sentolo; 33: Donomulyo; 34: Tanjungharjo; 35: Banyuroto; 36: Pendoworejo.

Measurement of Abiotic Factors

The abiotic factors measured at each location included air temperature, air humidity, wind speed, and light intensity. Air temperature and humidity were measured using thermohygrometer, light intensity measured using lux meter, and wind speed was measured using anemometer. Measurements were taken three times, namely at the beginning, middle, and end of sampling.

Rearing of *S. frugiperda* eggs and Parasitoid Observation

Each egg packages that were obtained from the field was transferred to a 130 mL plastic cup and labelled with the location. The eggs are incubated until they hatch into *S. frugiperda* larvae or *T. remus* parasitoids. Fibres on the eggs were cleaned with a soft brush, then the eggs are counted using a hand counter to determine the number of parasitised (black) and unparasitised (white) eggs. The hatched parasitoids were preserved in microtubes containing 96% alcohol.

Telenomus remus identification

Identification of *T. remus* was carried out using a stereo microscope based on morphological characteristics referring to Yang et al. (2019), Oktaviana et al. (2022), and Harahap & Siregar (2024). The characteristics observed included body colour, antenna shape, wing shape, abdomen shape, and morphological differences between males and females.

Calculation of the Parasitization Rate of *T. remus* on *S. frugiperda* Eggs

The parasitization rate of *T. remus* was calculated by counting the number of parasitised eggs, then averaging the value based on the number of egg groups observed. The parasitization rate was calculated using the formulae of Buchori et al. (2010) and Jamili & Haryanto (2015):

$$P \equiv \frac{n}{N} \times 100\% \quad (1)$$

The percentage of *T. remus* parasitism on *S. frugiperda* eggs will be categorised based on predetermined percentage ranges and modified according to the parasitization ranges according to Williams and Williams, (1998) (Table 1).

Table 1. Categories of *T. remus* parasitization rates on *S. frugiperda* eggs (modified from Williams & Williams, 1998)

Parasitism rate (%)	Notes
90 – 100	Very high
51 – 89	High
30 – 50	Moderate
1 – 29	Low

Calculation of the Parasitization Rate of *T. remus* on *S. frugiperda* Eggs

The parasitism rate was calculated by comparing the number of parasitoids that successfully emerged with the number of host eggs that had been parasitised (Delpopi et al., 2015). The parasitism rate was calculated using a formula adapted from Hakiki (2015).

$$P \equiv \frac{a}{A} \times 100\% \quad (2)$$

Determination of *T. remus* sex ratio

The sex of *T. remus* was determined by observing specimens under a stereo microscope, examining the morphological characteristics that distinguish males and females (Figure 2). Based on the results of research by Yang et al. (2019) and Oktaviana et al. (2022), the sex differences in *T. remus* can be seen from the number and shape of the antenna segments, body colour, and the presence of an ovipositor. Females have antennae that are longer than the head with 11 segments and a distinct 'clava' tip, while males have shorter antennae with 12 segments without a prominent clava. In addition, females are darker in colour with a prominent ovipositor at the end of the abdomen that looks like a fine needle, while males are brighter yellowish in colour without an ovipositor. The following is an image showing the morphological differences between male and female *T. remus*.



a b

Figure 2. The difference between male and female *Telenomus remus*, a. male and b. female.

Calculation of sex ratio of *T. remus*

The sex ratio was calculated to determine the ratio of male to female *T. remus* imagoes emerging from *S. frugiperda* eggs. The calculation was performed using the formula according to Oktaviani et al. (2022).

$$Sex\ ratio = \frac{\text{total of female imagoes}}{\text{total of male imagoes}} \quad (3)$$

Data Analysis

Descriptive analysis was used to describe the levels of parasitism, parasitisation, and sex ratio comparison of *T. remus*. Correlation test was used to determine the relationship between the number of *S. frugiperda* eggs and the levels of parasitism and parasitisation.

RESULTS AND DISCUSSION

Parasitisation rate of *Telenomus remus* on *S. frugiperda*

Based on field observations, the results varied considerably. The highest level of *T. remus* parasitisation of *S. frugiperda* eggs was found in Wates and Girimulyo subdistricts. Meanwhile, the lowest levels of parasitism were found in Sentolo and Samigaluh (Figure 2). The level of parasitisation of *T. remus* on *S. frugiperda* eggs in Kulon Progo Regency was found to be high, ranging from 60.62 to 76.42%. The subdistricts with the highest parasitisation were Wates (76.42%) and Girimulyo (74.79%), while the lowest parasitisation was found in Samigaluh (60.62%) and Sentolo (62.24%).

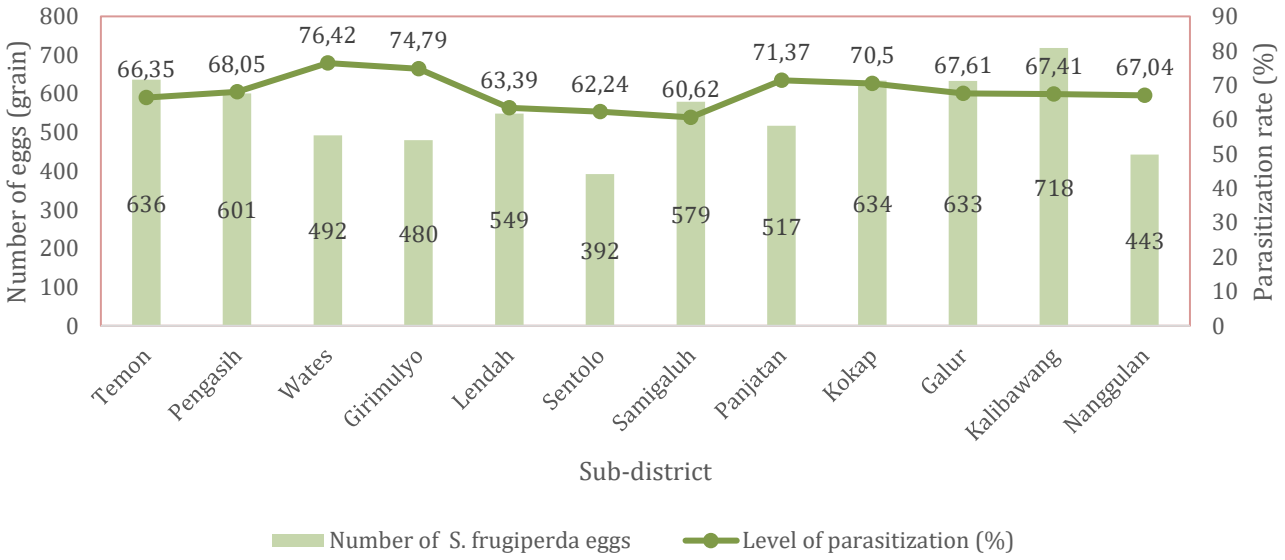


Figure 3. Number of eggs and percentage of *T. remus* parasitisation on *S. frugiperda* eggs in Kulon Progo

This high parasitisation rate indicates that *T. remus* is capable of parasitising most of the *S. frugiperda* eggs found in the field. The high parasitisation rate is influenced, among other things, by the abundance of hosts. The more *S. frugiperda* eggs are available, the greater the chance for *T. remus* to find and parasitise the eggs. This is in line with the opinion of Junaedi et al. (2016), who stated that the abundant availability of hosts can increase the activity and parasitisation rate of parasitoids. The abundance of eggs is supported by the behaviour of *S. frugiperda*, which lays eggs in large groups, so that the eggs are concentrated in one place and make it easier for parasitoids to find hosts and lay eggs (Liao et al, 2019).

The egg mass of *S. frugiperda* has morphological protection in the form of scale-hair and a layered egg arrangement, which can be an obstacle for egg parasitoids. However, certain egg parasitoids have been reported to overcome these barriers by cleaning the scales, exploiting gaps between eggs, and shifting the upper layer of eggs so

that the lower eggs remain accessible (Yang et al., 2019). This ability may support the high egg parasitism found in this study. Cave (2000) explained that the scale cover and layered egg arrangement in *Spodoptera* egg masses are strong barriers to small egg parasitoids such as *Trichogramma*, so that generally only some eggs (especially the top layer) can be parasitised. However, *T. remus* is reported to be more aggressive due to its larger body size, enabling it to reach eggs deep within the egg mass despite the scales and layers. This aligns with the report by Kenis et al. (2019) that *T. remus* can parasitise the entire egg mass, whereas *Trichogramma* tends to parasitise only the outer layer.

Paratisim Rate of *T. remus* to S. *frugiperda Eggs*

The results showed variations in the number of parasitised eggs, the level of parasitism, and the number of *T. remus* imagoes that successfully emerged between locations. In general, the number of parasitised eggs ranged from 244 to 484 eggs, with a parasitism rate of 36.17–54.14%, while the emergence of *T. remus* ranged from 89 to 245 individuals (Table 2).

Table 2. Number of parasitised eggs, parasitism rate and occurrence of *T. remus* imagoes in Kulonprogo.

Sub-districts	Parasitized eggs (grain)	Parasitism rates (%)	Emerging of *T. remus imagoes* (individual)
Temon	422	38.86	164
Pengasih	409	36.19	148
Wates	376	36.17	136
Girimulyo	359	36.77	132
Lendah	348	42.53	148
Sentolo	244	36.48	89
Samigaluh	351	37.61	132
Panjatan	369	47.15	174
Kokap	447	54.14	242
Galur	428	45.09	193
Kalibawang	484	50.62	245
Nanggulan	443	39.39	117

Based on previous research, *T. remus* was able to parasitise *S. frugiperda* eggs at a relatively high rate in Kulon Progo. However, when viewed from the success of development to the imago stage, Table 2 shows that the parasitism rate was only in the range of 36.17–54.14%, meaning that not all parasitised eggs successfully produced adult *T. remus*. This failure may occur because the development of parasitoids is influenced by the age of the host eggs. *Telenomus remus* is known to prefer and be more successful with young eggs (1–2 days old), while older eggs are less suitable, so that many remain parasitised but their emergence success rate decreases (Peñaflor et al., 2012).

The age of *S. frugiperda* eggs can be estimated descriptively based on colour changes. Young eggs usually appear whitish green, while older eggs that are close to hatching tend to turn greyish brown (Karlina et al., 2022). Based on observations, the large number of dark brown eggs indicates that some of the eggs found are likely to be in an advanced stage of development (close to hatching). This condition can reduce the chances of *T. remus* successfully developing into imagoes even if oviposition occurs, thereby lowering the parasitism rate. Another influential factor is superparasitism (the host egg receives more than one parasitoid egg), for example when the parasitoid density is high or the eggs are exposed for too long. This situation can cause competition between larvae inside the egg, so that some fail to develop and do not emerge as imagoes (Lü et al., 2024).

In addition to these biological factors, exposure to pesticides has the potential to widen the gap between parasitism and parasitism. Pesticides not only affect parasitism, but can also reduce parasitism through death or decreased activity of imagoes when searching for hosts. The more imagoes exposed to pesticides, the more imagoes will die. This can reduce the level of parasitism of parasitoids on their hosts. However, under certain conditions, pesticides do not always immediately stop the activity of *T. remus*. For example, *T. remus* may have already

oviposited before spraying, or the adults may only have been lightly exposed so that they are still able to search for hosts. In such situations, parasitism can still occur and appear to remain high. However, pesticide residues adhering to leaves or egg masses can interfere with the development of *T. remus* in the immature stage inside the host egg, resulting in lower parasitism rates (Carmo et al., 2010).

The parasitism and parasitisation rates were then tested using a correlation test to determine whether there was a relationship between the parasitism rate and the parasitisation rate of *T. remus* on *S. frugiperda* eggs. The results of the correlation test showed that the relationship between the level of parasitism and the level of parasitism of *T. remus* on *S. frugiperda* eggs obtained a p value > 0.05, so it can be concluded that the two variables are not correlated (Table 3).

Table 3. Correlation between parasitisation rate and parasitism rates of T. *remus* to S. *frugiperda eggs*

		Parasitization	**Parasitisme** (*Parasitism*)
Parasitasi (*Parasitization*)	**Correlation coefficien**	1.000	-.028
	Sig. (2-tailed)		**.931**
	N	12	12
Parasitisme (*Parasitism*)	**Correlation coefficien**	-.028	1.000
	Sig. (2-tailed)	**.931**	
	N	12	12

The results of this study confirm that the success of *T. remus* in parasitising host eggs does not directly determine the success of the parasitoid in developing into an adult imago (Lü et al., 2024). Thus, the success of becoming an adult is more influenced by post-oviposition factors, particularly the age or quality of the host egg when parasitised (Penaflor et al., 2012) and the internal condition of the egg, which determines the adequacy of nutrients for the development of the parasitoid larva (Ulva et al., 2023). In addition, pesticide exposure in the field also has the potential to reduce emergence success because it can inhibit the development of the immature phase within the egg, even though oviposition has already occurred (Silva et al., 2016).

***Sex ratio* of *T. remus* from *S. frugiperda* Eggs**

Based on Table 4, the *T. remus* population across all subdistricts shows a predominance of females. The male:female sex ratio varies between subdistricts, ranging from 1:2 in Samigaluh Subdistrict to 1:48 in Pengasih Subdistrict.

Table 4. Number of male and female imagoes and the sex ratio of *Telenomus remus*

Sub-districts	**Male (individual)**	**Female (individual)**	**Sex ratio**
Temon	17	147	1:9
Pengasih	3	145	1:48
Wates	13	123	1:9
Girimulyo	20	112	1:6
Lendah	21	127	1:6
Sentolo	6	83	1:14
Samigaluh	45	87	1:2
Panjatan	21	153	1:7
Kokap	45	197	1:4
Galur	13	180	1:14
Kalibawang	55	190	1:3
Nanggulan	12	105	1:9

This female-biased sex ratio pattern is consistent with the biological characteristics of egg parasitoids of the order Hymenoptera, as reported in various studies on *T. remus* and other egg parasitoids (Waage & Hassell, 1982;

Hardy, 2002). Ustriyana et al. (2025) also reported female dominance in *T. remus* populations parasiting *S. frugiperda* eggs with a male:female ratio of 1:3, while Sari et al. (2020) showed that the proportion of *T. remus* females developing from *S. frugiperda* eggs in the laboratory always exceeded 50%. The similarity of these patterns indicates that the female-biased sex ratio is a relatively stable biological trait in *T. remus*.

The female dominance obtained in this study is related to the sex allocation strategy of *T. remus* towards host quality. The high proportion of females that emerged in most subdistricts indicates that the parasitised *S. frugiperda* eggs were of sufficient quality to support the development of female individuals. According to the sex allocation theory, parasitoid parents tend to allocate female offspring to hosts with higher nutritional quality, while male eggs are more tolerant of hosts with lower quality (Hardy, 2002). This condition is in line with the results of research by Sari et al. (2020), which states that *S. frugiperda* eggs are suitable hosts for the development of *T. remus*, especially in female, thus enabling the formation of a sex ratio biased towards females as observed in this study.

The correlation between the level of parasitisation, the level of parasitism, and the sex ratio of *T. remus* to *S. frugiperda* eggs shows that there is no significant relationship between the three variables. The results of the correlation test between the level of parasitism, the level of parasitism, and the sex ratio of *T. remus* to *S. frugiperda* eggs are presented in Table 5.

Table 5. Correlation between parasitisation rates, parasitism rates, and sex ratio *T. remus* to S. *frugiperda* eggs

		Parasitisation rates	Parasitism rates	Sex ratio
Sex Ratio	**Correlation coefficien**	.147	-.476	1.000
	Sig. (2-tailed)	.649	.118	.
	N	12	12	12

The correlation between parasitisation rates and sex ratio was also insignificant (r = 0.147; p = 0.649). Meanwhile, the relationship between parasitism levels and sex ratio showed a moderate negative correlation coefficient (r = −0.476), but was statistically insignificant (p = 0.118). The dominance of female individuals in the *T. remus* population found in this study indicates that *S. frugiperda* eggs in the field generally have sufficient quality to support the development of female offspring. However, when the relationship between sex ratio was further analysed together with parasitisation rates and parasitism rates, the correlation test results showed that the three parameters were not significantly correlated with each other.

The absence of a significant relationship between the parasitism rate and sex ratio indicates that the ratio of males to females in *T. remus* is more influenced by the quality of the host eggs than by the number of parasitised eggs. In egg parasitoids, parasitoid parents tend to produce female offspring in hosts of better quality, while lower-quality hosts more often produce males (Hardy, 2002). The absence of a significant relationship between parasitism levels and sex ratio indicates that the success of *T. remus* in developing to the adult stage does not directly determine the ratio of males to females that emerge. In other words, even though a number of host eggs successfully produce adult parasitoids, this condition is not always followed by a change in sex ratio.

CONCLUSION

Telenomus remus showed a high level of parasitisation rates of *S. frugiperda* eggs in Kulon Progo Regency, with moderate parasitism levels and a sex ratio dominated by females. Correlation test results showed that the level of parasitism, parasitism rate, and sex ratio were not significantly correlated with each other. These findings indicate that the success of parasitoid development is more influenced by the quality of host eggs than by the number of parasitised eggs.

AUTHORS CONTRIBUTIONS

CA collecting the samples, identification of parasitoid, analyze the data, and writing the manuscript. ILIP designed the research, identification of parasitoid, analyze the data, writing te manuscript. The authors provided

responses and comments on the research flow, data analysis, and interpretation as well as the shape of the manuscript. All the authors have read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Buchori, D., Meilin, A., Hidayat, P. & Sahari,.B. 2010. Species distribution of Trichogrammaand Trichogrammatoidea genus (Tricho-grammatoidea: Hymenoptera) in Java. *J.ISSAAS*, 16(1), 83- 96.

Bueno, R. C. O. de F., Carneiro, T. R., Bueno, A. de F., Pratissoli, D., Fernandes, O. A., & Vieira, S. S. (2010). Parasitism capacity of *Telenomus remus* Nixon (Hymenoptera: Scelionidae) on Spodoptera frugiperda (Smith) (Lepidoptera: Noctuidae) eggs. *Brazilian Archives of Biology and Technology*, 53(1), 133-139. https://doi.org/10.1590/S1516-89132010000100017

Carmo, E. L., Bueno, A. F., & Bueno, R. C. F. (2010). Pesticide selectivity for the insect egg parasitoid *Telenomus remus* (Hymenoptera: Scelionidae). *BioControl*,*55*(5), 455–464. https://doi.org/10.1007/s10526-010-9269-y

Cave, R.D. 2000. Biology, ecology and use in pest management of *Telenomus remus*. *Biocontrol News and Information*. 21(1), pp. 21–26.

Colmenarez, Y. C., Babendreier, D., Ferrer Wurst, F. R., Vásquez-Freytez, C. L., & Bueno, A. F. (2022). The use of *Telenomus remus* (Nixon, 1937) (Hymenoptera: Scelionidae) in the management of Spodoptera spp.: potential, challenges and major benefits. *CABI Agriculture and Bioscience,* 3(5), 1–14. https://doi.org/10.1186/s43170-021-00071-6

Delpopi, M., Zamani, N. P., Soedharma, D., & Johan, O. 2015. Prevalensi, Insidensi dan Perkembangan *Black-band Disease* pada Karang Scleractinia (*Montipora* spp) di Perairan Dangkal Gugusan Pulau Pari. *Ilmu Kelautan: Indonesian Journal of Marine Sciences*, 20(1), pp.52-60. https://doi.org/10.14710/ik.ijms.20.1.52-60

Hakiki, A., Karindah, S., & Mudjiono, G. (2015). Jurusan Hama dan Penyakit Tumbuhan, Fakultas Pertanian, Universitas Brawijaya Jl. Veteran, Malang 65145. *Jurnal HPT*, 3(April), 91–99.

Harahap, M. H., & Siregar, A. Z. (2024). Eksplorasi parasitoid telur (Spodoptera frugiperda) pada berbagai varietas tanaman jagung di Desa Sumber Melati Diski, Kabupaten Deli Serdang. Jurnal Agrifor, 23(1), 101–108. https://doi.org/10.31293/agrifor.v23i1.7057

Hardy, I. C. W. (Ed.). (2002). *Sex ratios: Concepts and research methods*. Cambridge University Press. https://doi.org/10.1017/CBO9780511542053

Herlinda, S., Suwandi, S., Irsan, C., Adrian, R., Fawwazi, F., & Akbar, F. (2023). Species diversity and abundance of parasitoids of fall armyworm, Spodoptera frugiperda (Lepidoptera: Noctuidae) from South Sumatra, Indonesia. *Biodiversitas*, 24(11), 6184–6190. https://doi.org/10.13057/biodiv/d241147

Hossain, M.Y., Jun, O., Ahmed, J., Saleha, J. & Robert, L.V.Jr. (2012). Life History Traits of the Monsoon River Prawn *Macrobrachium malcolmsonii* (Milne-Edwards, 1844) (Palaemonidae) in the Ganges (Padma) River Northwestern Bangledesh. *Journal of Freshwater Ecology*, 27(1), 131-142. https://doi.org/10.1080/02705060.2011.633739

Jamili, A., & Haryanto, H. (2015). Keanekaragaman dan parasitisasi parasitoid telur Leptocorisa acuta pada berbagai pola tanam padi. *Agrotrop: Journal on Agriculture Science*. https://doi.org/10.21776/ub.agrotrop.2015.026.01.08

Junaedi, E., Yunus, M., Hasriyanty, H. 2016. Jenis Dan Tingkat Parasitasi Parasitoid Telur Penggerek Batang Padi Putih (*Scirpophaga innotata* Walker) Pada Pertanaman Padi (Oryza sativa L.) Di Dua Ketinggian Tempat Berbeda Di Kabupaten Sigi. *Agrotekbis: Jurnal Ilmu Pertanian (e-journal)*, 4(3), pp.280-287.

Karlina, D., Samharinto, & Rosa, H. O. (2022). Biologi ulat grayak (*Spodoptera frugiperda* J. E. Smith). *Proteksi Tanaman Tropika*, *5*(2), 524–532. https://doi.org/10.20527/jptt.v5i3.1493

Kenis, M., du Plessis, H., Van den Berg, J., Ba, M. N., Goergen, G., Kwadjo, K. E., Baoua, I., Tefera, T., Buddie, A., Cafà, G., Offord, L., Rwomushana, I., & Polaszek, A. (2019). *Telenomus remus*, a candidate parasitoid for the biological control of Spodoptera frugiperda in Africa, is already present on the continent. *Insects*, 10(4), 92. .https://doi.org/10.3390/insects10040092

Lacerda, L. F. de, Coelho Jr, A., de Paula, P., Amorim, D. J., Demetrio, C. G. B., & Parra, J. R. P. (2023). Biological basis for adoption of an isoline of *Telenomus remus* (Hymenoptera: Scelionidae) for an augmentative biological-control program for Spodoptera frugiperda (Lepidoptera: Noctuidae). *Journal of Insect Science*, 23(5), 1–7. https://doi.org/10.1093/jisesa/iead045

Laminou, S. A., Ba, M. N., Karimoune, L., Doumma, A., & Muniappan, R. (2020). Parasitism of locally recruited egg parasitoids of the fall armyworm in Africa. *Insects*, 11(7), 430. https://doi.org/10.3390/insects11070430

Liao, Y.-L., Yang, B., Xu, M.-F., Lin, W., Wang, D.-S., Chen, K.-W., & Chen, H.-Y. (2019). First report of *Telenomus remus* parasitizing Spodoptera frugiperda and its field parasitism rate in southern China. In E. Talamas (Ed.), Advances in the systematics of Platygastroidea II. *Journal of Hymenoptera Research*, 73, 95–102. https://doi.org/10.3897/jhr.73.39057

Lü Y., Zhang L., Li X., Wang Y. & Chen H. 2024. Evaluation of key factors for mass rearing the egg parasitoid *Telenomus remus* Nixon (Hymenoptera: Scelionidae). *J. Appl. Entomol*. 148: 1–10. https://doi.org/10.1186/s43170-024-00263-w

Mercer, N. (2020). *Insect parasitoids: Important natural enemies of pests* (Entfact-018). University of Kentucky.

Muliani, Y., & Srimurni, R. R. (2022). *Parasitoid dan predator pengendali serangga hama*. CV Jejak.

Mursyidin, A. H., Suana, I. W., Ubaidillah, R., & Sutrisno, H. (2024). Keanekaragaman dan potensi parasitoid sebagai pengendali alami ulat grayak Spodoptera frugiperda (Smith) (Lepidoptera: Noctuidae) pada pertanaman jagung lahan kering. *Jurnal Entomologi Indonesia*, 21(3), 200-212. https://doi.org/10.5994/jei.21.3.200

Nonci, N., Kalqutny, S. H., Mirsam, H., Muis, A., Azrai, M., & Aqil, M. (2019). Pengenalan Fall Armyworm (Spodoptera frugiperda J.E. Smith): Hama baru pada tanaman jagung di Indonesia. Balai Penelitian Tanaman Serealia, Badan Penelitian dan Pengembangan Pertanian, Kementerian Pertanian. Retrieved from https://repository.pertanian.go.id/handle/123456789/8673

Nurkomar, I., Putra, I. L. I., Buchori, D., & Setiawan, F. (2024). Association of a global invasive pest Spodoptera frugiperda (Lepidoptera: Noctuidae) with local parasitoids: Prospects for a new approach in selecting biological control agents. *Insects*, 15(3), 205. https://doi.org/10.3390/insects15030205

Oktaviani, V., Maryana, N., & Pudjianto. (2022). *Telenomus remus* (Nixon) (Hymenoptera: Scelionidae) biology and life table on Spodoptera frugiperda (J. E. Smith) (Lepidoptera: Noctuidae) eggs. *IOP Conference Series: Earth and Environmental Science*, 950(1), 012024. https://doi.org/10.1088/1755-1315/950/1/012024

Pabbage, M. S., & Tandiabang, J. (2007). Parasitasi Trichogramma evanescens Westwood (Hymenoptera: Trichogrammatidae) pada berbagai tingkat populasi dan generasi biakan parasitoid terhadap telur penggerek batang jagung Ostrinia furnacalis Guenée. *Agritrop: Jurnal Ilmu-Ilmu Pertanian*, 26(1), 41–50.

Peñaflor M.F.G.V., Sarmento M.M.D.M., Silva C.S.B., Werneburg A.G. & Bento J.M.S. 2012. Effect of host egg age on preference, development and arrestment of *Telenomus remus* (Hymenoptera: Scelionidae). Eur. *J. Entomol*. 109: 15–20. https://doi.org/10.14411/eje.2012.003

Pu'u, Y. M. S. W., & Syatrawati. (2022). Potensi pengendalian hayati hama *Spodoptera frugiperda* untuk keberlanjutan produksi jagung. *AGRICA: Journal of Sustainable Dryland Agriculture*, *15*(2), 144–160. https://doi.org/10.37478/agr.v15i2.2313

Purba, R., Manalu, R. S., Simamora, T. G., & Harefa, M. S. (2023). Interaksi organisme terhadap perubahan lingkungan: Studi kasus dalam ekologi hutan. *Jurnal Wilayah, Kota dan Lingkungan Berkelanjutan* (JWIKAL), 2(2), 100–108.

Qu, Y., Chen, X., Monticelli, L. S., Zhang, F., Desneux, N., Huijie, D., Ramirez-Romero, R., & Wang, S. (2020). Parasitism performance of the parasitoid Trichogramma dendrolimi on the plum fruit moth Grapholitha funebrana. *Entomologia Generalis*, 40(4), 385-395. https://doi.org/10.1127/entomologia/2020/1059

Sari, A., Buchori, D., & Nurkomar, I. (2020). The potential of *Telenomus remus* Nixon (Hymenoptera: Scelionidae) as biocontrol agent for the new fall armyworm Spodoptera frugiperda (Lepidoptera: Noctuidae) in Indonesia. *Planta Tropika: Jurnal Agrosains, (*8(2), 69-74. https://doi.org/10.18196/pt.2020.116.69-74

Sari, A., Buchori, D., & Nurkomar, I. (2021). Effect of host-larval diet on the host acceptance and host suitability of the egg parasitoid *Telenomus remus* Nixon (Hymenoptera: Scelionidae) on Spodoptera frugiperda J. E. Smith (Lepidoptera: Noctuidae). *Jurnal Hama dan Penyakit Tumbuhan Tropika*, 21(2), 158–165. https://doi.org/10.23960/jhpt.v21i2.2857

Silva, D. M. da, Bueno, A. de F., Andrade, K., Stecca, C. dos S., Neves, P. M. O. J., & Moscardi, F. (2016). *Selectivity of organic compounds to the egg parasitoid Telenomus remus Nixon (Hymenoptera: Platygastridae)*. *Semina: Ciências Agrárias*, 37(1), 55–66. https://doi.org/10.5433/1679-0359.2016v37n1p55

Stone, E. A., Shackelford, T. K., & Buss, D. M. (2007). Sex ratio and mate preferences: A cross-cultural investigation. *European Journal of Social Psychology*, 37(2), 288–296. https://doi.org/10.1002/ejsp.357

Ustriyana, I. N. G., et al. (2025). *The potential of Telenomus remus Nixon (Hymenoptera: Scelionidae) as a biological control agent for Spodoptera frugiperda in Flores, East Nusa Tenggara, Indonesia*. *IOP Conference Series: Earth and Environmental Science*, 1469(1), 012026. https://doi.org/10.1088/1755-1315/1469/1/012026

Ulya, Q., Muhlison, W., Purnomo, H., & Sucipto, I. (2023). *Pengaruh pemberian media pakan terhadap volume telur dan tingkat parasitasi Trichogramma sp. Jurnal Agrotek Tropika*, 12(1), 138–145. https://doi.org/10.23960/jat.v12i1.6118

Waage, J. K., & Hassell, M. P. (1982). Parasitoids as biological control agents–a fundamental approach. *Parasitology*, 84(4), 241-268.

Williams, E.H., Williams, L.B. 1998. Parasites of Offshore Big Game Fishes of Puerto Rico and the Western Atlantic. *Journal of Parasitology.* 84(2), p.283.

Wulandari, R., & Widjayanti, T. (2021). Strategi pengendalian ulat grayak jagung (Spodoptera frugiperda) melalui pendekatan pengendalian hama terpadu. *Jurnal Agribest*, 5(2), 126–135.

Yang, S., Zhang, L., Zhao, X., Huo, L., Zhou, J., & Dong, H. (2019). A method for identifying sexuality of *Telenomus remus* wasps and the behavioral characteristics of *Telenomus remus* against *Spodoptera frugiperda* eggs. *Plant Protection*, *45*(S1), 1–10. https://doi.org/10.16688/j.zwbh.2019496