



ADULT EMERGENCE PERFORMANCE OF *Trissolcus semistriatus* Nees (HYMENOPTERA: SCELIONIDAE) AND *Telenomus turesis* Walker (HYMENOPTERA: PLATYGASTRIDAE) ON SUNN PEST EGGSÇisem Nur GÖVEN^{1,a}, Tolga AYSAL^{1,b,*}¹Tekirdağ Namık Kemal University, Faculty of Agriculture, Department of Plant Protection

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ABSTRACT. *Eurygaster integriceps* Puton (Sunn pest) is the common pest that causes economic loss on wheat. Egg parasitoids have been used successfully in biological control studies against Sunn pest. The intraspecific or interspecies behavior of these parasitoids affects the success of biological control. Therefore, in this study, adult emergence rates were investigated in eggs parasitized by *Trissolcus semistriatus* Nees and *Telenomus turesis* Walker, which are egg parasitoids of sunn pest. The experiments were carried out in two different applications. In the first experiment; one *T. semistriatus* and one *T. turesis* female were given to different numbers of sunn eggs (2-4-8 packs) in the same conditions. In the second experiment; Three *T. semistriatus* and one *T. turesis* female were given to 8 packs of Sunn pest eggs in the same conditions. Then the experiment was repeated in the opposite way. Total adult emergence rate in experiments given one *T. semistriatus* and one *T. turesis* female; It was found to be higher in *T. semistriatus* in 2 and 4-pack egg applications. *T. semistriatus* constituted 72,40% of the total adult emergence rate in eggs given three *T. semistriatus* and one *T. turesis* female. The emergence rate of *T. turesis* was calculated as 55,65% among the total emergence rate in eggs given by three *T. turesis* and one *T. semistriatus* female. In conclusion; In the experiments where two parasitoids were compared, it was concluded that *T. semistriatus* was more successful in competition in terms of adult emergence rate.

Keywords: *Eurygaster integriceps*, *Trissolcus semistriatus*, *Telenomus turesis*, Adult emergence rate, Competition

INTRODUCTION

Wheat, which is important and indispensable for humans, is a source of carbohydrates and protein, and it comes to the fore in the food market [1]. For this reason, it stands out as the most cultivated and produced plant among cultivated plants in the world. Wheat constitutes 28% of the total 2,8 billion tons of grain production in the world Tarımsal Ekonomi ve Politika Geliştirme Enstitüsü [2]. According to the data for 2021, it was planted in an area of 220,759,739 hectares and 770,877.072,89 tons were produced [3]. Wheat has adapted to all kinds of climates and soil conditions with its many varieties. As a result, it can be grown in a wide area of the World [4]. It is very important for human nutrition. In addition, the economic value of wheat also has an effect on the economic power between countries. Turkey is an importer in the international market in terms of wheat production [5].

Like all cultivated plants, wheat is exposed to many pests. One of the most important of these pests is the *Eurygaster integriceps* (Hemiptera: Scutelleridae). There are 15

species known in the world belonging to the genus *Eurygaster* known as the Sunn pest. Seven of these species are found in our country [6]. In the Thrace Region, the most common species is *E. integriceps* [7,8,9,10].

Sunn pest is the main pest of cereals, preferring primarily wheat. Adults and nymphs feed by sucking plant sap with their stinging-sucking mouth structures. If sunn pest is not controlled, the damage to the plant can reach 100% [11]. IPM (Integrated Pest Management) is applied in the control of Sunn pest. Although chemical control is mainly applied in this program, biological control practices are also included [12].

Sunn pest has many natural enemies in nature. Among these, the species belonging to the genus *Trissolcus*, which is in the Scelionidae family of the Hymenoptera order, are very important [13-25]. It has been reported that *Trissolcus* species are common in Turkey, and 22 different *Trissolcus* species have been identified [7,10,13,14,17-19,22,23,25-35] It has been reported that the most important egg parasitoids among these species are *T. semistriatus* and *Trissolcus grandis*, and they are found in all our regions [14,34]. *T. semistriatus* is the most common of these species in the Thrace Region [10].

Apart from *Trissolcus* species, which are natural enemies of sunn pest, it is known that *Telenomus* species also exist. It is reported that 600 species in the World belong to the genus *Telenomus*. *Telenomus* species are egg parasitoids of many insects. In addition, the sunn pest is an important egg parasitoid and it is stated that this pest can suppress its population [36-41]. One of the important parasitoids in this genus is *Telenomus turesis* (synonym *Telenomus chloropus*) [42].

It is known that *Trissolcus* and *Telenomus* species are one of the main controlling factors on the population of Pentatomidae species. Some species of these parasitoids are reported to be effective in controlling populations of pests such as *E. integriceps* and *Nezara viridula* [36].

Egg parasitoids are successfully used in biological control studies due to their host specificity. The relationship of parasitoid species present in the field with each other is effective in the success of biological control. Among these relationships, competitive relationships on the same host egg are important. This study was carried out to observe the adult emergence competition between *T. semistriatus* and *T. turesis* species and to reveal which species is dominant.

MATERIALS AND METHODS

Material

The main material of the study is *Eurygaster integriceps* Puton and its egg parasitoids *Trissolcus semistriatus* Nees and *Telenomus turesis* Walker collected from wheat fields in Tekirdağ Süleymanpaşa district.

Method

All production studies and experiments were carried out under 26±1°C temperature, 60±10% humidity, 16:8 hour photoperiod conditions.

***Eurygaster integriceps* Egg Culture**

Eurygaster integriceps adults were collected from wheat fields for the production of host eggs used in the experiments. The collected adults were placed in cages (20x27 cm) containing germinated wheat plants and wheat ears. Eggs laid with daily controls were collected and used in experiments and parasitoid production.

Parasitoid Production

The identifications of *T. semistriatus* and *T. turesis* individuals used in the experiments were made by Prof. Dr. Müjgan KIVAN. Species were obtained from laboratory cultures of Tekirdağ Namık Kemal University, Faculty of Agriculture, Department of Plant Protection. Parasitoids were grown in glass tubes sealed with cotton. They were given 30% sugar water impregnated on blotting papers (1x5 cm) for their feeding [43]. Daily *E. integriceps* egg packs were given as host.

Adult Emergence Experiments

In the experiments, females that were 1-2 days old and mated for 24 hours were used. Daily *E. integriceps* egg packs obtained from laboratory culture were given as hosts. The parasitoids are left to parasitize the eggs for 24 hours. At the end of this period, they were removed from the eggs. The species and sexes of *T. semistriatus* and *T. turesis*, which emerged from the parasitized eggs as a result of the adult emergence experiments, were recorded.

Experiments were set up in two different sets [44]. On the first experiment set; adult emergence was observed when a *T. semistriatus* and a *T. turesis* female were given to different numbers of sunn pest eggs in the same environment. For this purpose, a *T. semistriatus* and a *T. turesis* female were left in glass petri dishes (5 cm) in which 2, 4, and 8 egg packs were placed daily. After 24 hours, the parasitized eggs were transferred to glass tubes and kept in the incubator for parasitoid growth. Thus, the adult emergence rates of the same number of females were determined when they were together.

In the second experiment set; adult emergence was observed when three *T. semistriatus* and one *T. turesis* female were given to the same number of sunn pest eggs. For this purpose, three *T. semistriatus* and one *T. turesis* female were left to parasitize on glass petri dishes (5 cm) in which 8 egg packs were placed daily. After 24 hours, parasitized eggs were taken into glass tubes and kept in the incubator for parasitoid development. In the next step, the experiment was repeated with three *T. turesis* and one *T. semistriatus* female. Thus, the adult emergence of different numbers of females in the same environment after parasitization was determined.

Data analysis

In the studies carried out under controlled conditions, the experiments were set up according to the randomized plot design. In the analyzes made with the data obtained, analysis of variance was applied in the form of one-way ANOVA in multiple comparisons. If the difference between the factors was found to be significant, grouping was made with Duncan's test ($p < 0,05$). In paired comparisons, independent group t-test was used. SPSS 16.0 package program was used in all analyses [45].

RESULTS AND DISCUSSION

Adult Emergence Competition Between *Trissolcus Semistriatus* And *Telenomus Turesis* Females

The results of the adult emergence experiments on different numbers (28-56-112) of sunn pest eggs given a *T. semistriatus* and a *T. turesis* female are given in Table 1. Investigating at the table, it is seen that there is a significant ($p < 0,05$) difference in adult

emergence between species and sexes when different numbers of egg packs are given to two species. The same was true for male individuals.

It was determined that the adult emergence rate of *T. semistriatus* females was higher than *T. turesis* when two packages of eggs were given to the parasitoids. In the experiments in which the adult emergence was followed on four packs of eggs, the male individual in *T. semistriatus* and the female individual in *T. turesis* had the highest emergence rate. When eight packs of eggs were given, it was determined that the highest and least adult emergence occurred in *T. turesis*, female (22,81±2.25) and male (4,91±1.33) sexes, respectively. Regardless of the number of egg packs given between the sexes, females hatched more than males in all experiments, except for *T. semistriatus* in the experiment, which was given four packs of sunn pest eggs.

The averages of adult emergence from egg packs given in different numbers were compared within each species and sex, and a statistically significant difference ($p < 0,05$) was found in all sexes and species, except for the adult emergence rate of *T. turesis* female (Table 1). In *T. semistriatus*, the highest rate of female adult emergence was realized in the application given two packs of eggs. The male adult emergence rate was found to be high in the application given four packs of eggs. It was determined that there was no difference in the female adult emergence rate of *T. turesis* when different numbers of egg packs were given. However, it was determined that the male adult emergence rate was higher in the four-pack egg application.

Table 1. Adult emergence rates of parasitoids from different numbers of *Eurygaster integriceps* eggs parasitized by *Trissolcus semistriatus* and *Telenomus turesis* females by species and sex

Number of eggs	Number of female individuals	Adult emergence rate (%) (Mean±SE) (min-max)			
		<i>T. semistriatus</i> ♀	<i>T. semistriatus</i> ♂	<i>T. turesis</i> ♀	<i>T. turesis</i> ♂
28	12	45,83±3,62 a*A** (25,00-71,43)	11,31±2,05 cB (3,57-21,43)	33,04±4,63 B (0-46,43)	7,44±2,35 cAB (0-32,14)
56	18	18,65±4,39 bB (0-48,21)	25,89±3,73 aA (1,79-62,50)	26,99±2,76 A (5,36-51,79)	13,20±2,89 bA (0-41,07)
112	20	13,17±2,23 bB (0-26,79)	7,77±1,61 bcB (0-24,11)	22,81±2,25 A (0-46,43)	4,91±1,33 cB (0-23,21)

*According to Duncan's test, there is no statistical difference between values that have the same lowercase letter in the same line ($p < 0,05$).

**According to Duncan test, there is no statistical difference between values that have the same capital letter in the same column ($p < 0,05$).

In the analysis comparing the total adult emergence rates in the egg packs of different numbers of the two species, a significant ($p < 0,05$) difference was found between the species (Table 2). According to the results obtained; It was observed that the adult

emergence of *T. semistriatus* was higher in the application given 2 packs of eggs compared to *T. turesis*, and lower in the application given 8 packs of eggs. When 4 packs of eggs were given, there was no statistically significant difference between the two species. However, on average, *T. semistriatus* had a higher adult emergence rate than *T. turesis*.

Table 2. Total adult emergence rates of two parasitoids given different numbers of *Eurygaster integriceps* eggs

Pack of eggs supplied (number of eggs)	Number of female individuals tested for each species	Total adult emergence rate (%) (Mean±standard error)	
		<i>T. semistriatus</i>	<i>T. turesis</i>
2 (28)	12	57,14±3,78 a*	40,48±4,04 b
4 (56)	18	44,55±11,03 a	40,18±10,16 a
8 (112)	20	20,94±2,02 b	27,72±2,15 a

*According to the *t*-test, there is no statistical difference between the values that have the same lowercase letter in the same line ($p < 0,05$).

In the experiments where two species parasitized different numbers of egg packs, the total adult emergence rates were calculated and it was observed that the highest adult emergence occurred in the application given 2 packs of eggs (97,62%). When 4 packs and 8 packs of eggs were given, the total adult emergence rates were determined as 84,72% and 48,66%, respectively.

Generally, it is seen that the percentage of adult emergence rates decreases with the increase in the number of eggs given. The reason for this is thought to be related to the daily parasitization rates of the species. Giving eggs to the species above the daily parasitization rates, caused an increase in the number of normally unparasitized eggs and/or unhatched eggs. For this reason, calculating the percentage of the adult hatching rate over the number of eggs given caused the adult hatching rates to be low. Although the adult hatching rates seem to be lower when the number of eggs given is increased, in fact, increasing the number of eggs has also increased the adult hatching rate as it reduces competition.

Köse [46] and Köse and Kıvan [47] conducted preferential and non-preferential experiments on intraspecific competition and superparasitism of *T. semistriatus* on sunn pest eggs. They found that the rate of parasitism decreased with increasing host density in adult competition experiments. They reported that there was no significant change in the parasitization rate when the parasitoid density increased. When 2-4-8 packages of eggs are given to two *T. semistriatus* females, they determined adult emergence rates of 0,97; 0,90; 0,66 respectively. All host eggs, whose adult emergence was completed, were examined under a stereomicroscope and they observed that there was almost no parasitism in the experiments given 8 egg packs. They also reported that the nymph output was very high in the same experiments. For this reason, explained that it is caused by giving more eggs than parasitoids can parasitize. Although this study was intraspecific competition, a similar finding was realized in our study.

In another study, it was stated that the number of eggs sufficient for daily parasitization of a female of *T. semistriatus* on *E. integriceps* eggs was 12-24 [48]. This study supports

the reason for parasitism and, accordingly, the decrease in adult emergence, in case the number of egg packs given per day is high in our study.

As a result of the experiments in which the species were given exactly; Looking at the adult emergence between the two species, it was determined that *T. semistriatus* was dominant against *T. turesis* in egg scarcity, when competition was high. Similar results were reported by Mahmoud and Lim [49], It has been explained that the probability of survival of *Telenomus* species is higher than that of *Trissolcus* species in their study.

Adult Emergence Competition Between Different Numbers of *Trissolcus Semistriatus* and *Telenomus Turesis* Females

Three *T. semistriatus* and one *T. turesis* female were given on sunn pest eggs and the adult emergence from these eggs was determined. When the findings obtained from the experiments were compared statistically, the difference between the species in terms of adult emergence was found to be significant ($p < 0,05$) (Table 3). In these experiments, the average adult emergence was 88,47%. *T. semistriatus* constituted 72,40% of the total adult emergence rate. When we compared in terms of genders, it was determined that *T. semistriatus* had higher adult emergence than *T. turesis* in both sexes.

Table 3. Parasitoid species, sex and total adult emergence rate (%) from *Eurygaster integriceps* eggs parasitized by three *Trissolcus semistriatus* and one *Telenomus turesis* female

Pack of eggs supplied (number of eggs)	Number of female individuals tested for each species	Species/Gender/Total	Adult emergence rate (%) (Mean±standard error) (Average min-max)
8 (112)	12	<i>T. semistriatus</i> ♀	35,12±3,23 c* (14,29-52,68)
8 (112)	12	<i>T. semistriatus</i> ♂	37,28±3,02 c (25,00-62,50)
8 (112)	12	<i>T. turesis</i> ♀	12,80±2,02 d (1,79-24,11)
8 (112)	12	<i>T. turesis</i> ♂	3,27±0,72 e (0,89-9,82)
8 (112)	12	<i>T. semistriatus</i>	72,40±1,30 b (62,50-77,68)
8 (112)	12	<i>T. turesis</i>	16,07±1,92 d (2,68-26,79)
8 (112)	12	Total	88,47±1,84 a (75,00-96,43)

*There is no statistical difference between the values with the same letter in the same column according to Duncan test ($p < 0,05$).

Three *T. turesis* and one *T. semistriatus* female were given on sunn pest eggs and adult emergence rates were determined in these eggs. When the findings obtained from the experiments were compared statistically, the difference between the species in terms of adult emergence was significant ($p < 0,05$) (Table 4). In these trials, where the total emergence rate was calculated as 84,67%, the average exit emergence of *T. turesis* was 55,65%. The emergence rate of *T. semistriatus* remained at 29,02%.

When we look at the experiments in which parasitoids were given at a ratio of three to one; *T. semistriatus* was found to be more dominant in competition than *T. turesis* in terms of adult emergence.

Table 4. Parasitoid species, sex and total adult emergence rate (%) from *Eurygaster integriceps* eggs parasitized by three *Telenomus turesis* and one *Trissolcus semistriatus* female.

Pack of eggs supplied (number of eggs)	Number of female individuals tested for each species	Species/Gender/Total	Adult emergence rate (%) (Mean±standard error) (Average min-max)
8 (112)	6	<i>T. semistriatus</i> ♀	13,69±8,99 e* (0-53,57)
8 (112)	6	<i>T. semistriatus</i> ♂	15,33±4,75 de (2,68-30,36)
8 (112)	6	<i>T. turesis</i> ♀	48,81±5,77 bc (20,54-58,04)
8 (112)	6	<i>T. turesis</i> ♂	6,85±0,82 e (5,36-10,71)
8 (112)	6	<i>T. semistriatus</i>	29,02±6,89 cd (8,93-59,82)
8 (112)	6	<i>T. turesis</i>	55,65±6,04 b (25,89-64,29)
8 (112)	6	Total	84,67±2,69 a (73,21-93,75)

*There is no statistical difference between the values with the same letter in the same column according to Duncan test ($p < 0,05$).

In the literature, no reference has been found on the activity, competition and/or adult emergence of *Telenomus turesis*. However; There are studies on the activities of different *Telenomus* species such as; *Telenomus podi* and *Trissolcus euschistis* on *Podisus maculiventris* eggs [50]; *Telenomus busseolae* and *T. isis* on *Sesamia calamistis* eggs [51]; *Trissolcus nigripedius* and *Telenomus gifuensis* on *Dolycoris baccarum* eggs [49] and *Telenomus podis* and *Trissolcus urichi* on *Piezodorus guildinii* eggs [52].

It is known that *T. semistriatus* and *T. simoni* are the most common species among the egg parasitoids of sunn pest in our country [10,15,18]. Kodan and Gürkan [16]. Investigated the population variation of *Trissolcus* species in wheat fields in Ankara and Konya provinces and identified *T. rufiventris* and *T. semistriatus* species. They reported that the dominant species among the two species in these regions was *T. semistriatus*.

In studies on adult emergence rate; Memişoğlu and Özer [19] determined that the adult emergence rate of *T. semistriatus* in *Eurygaster maura* eggs varied between 38,80-83,00%. Kıvan [19], found that the adult emergence rate of *T. semistriatus* in *E. integriceps* eggs was 88,52% and 95,34% in her study conducted in 1996-1997. Mi et al. [53], found the adult emergence rates between 97,3% and 96,6% in *Halyomorpha halys* eggs of *Trissolcus japonicus*. Since these results were obtained from different conditions, hosts and/or non-competitive environments, there are similarities as well as differences with our findings.

Cusumano et al. [54], in their research with *T. basalis* and *T. urichi* species; revealed that the competition of the first egg-laying species is higher than the other species. Köse [46], found the adult emergence rates to be 0,97; 0,89, and 1,00 in her experiments comparing the intraspecific competition of *T. semistriatus*. Kıvan and Aysal [55], investigated the competition between *T. semistriatus* and *T. simoni*; stated that *T. semistriatus* (56%) was superior to *T. simoni* (40%) in terms of adult emergence rate. In their observations made under the stereomicroscope, they observed that *T. semistriatus* was the first species that came to the eggs to parasitize and started to parasitize. They also reported that *T. semistriatus* constantly attacked and kidnapped *T. simoni*. As a result, the opinion that *T. semistriatus* is dominant is the same as in our study.

Queiroz et al. [56], studied the competition between the parasitoid *Telenomus podiis* and *Trissolcus teretis* of *Diceraeus melacanthus* and *Euschistus heros* eggs. As a result, they determined that the species that parasitized the eggs first was more successful in emergence competition. They stated that it is not appropriate to release both species together in biological control. However, they reported that the simultaneous release of more than one species to help preserve the natural diversity is important in terms of ensuring the continuity of the species in nature. Giovannini et al. [57], on the other hand, looked at the effect and competition of *Trissolcus japonicus* and *T. mitsukurii* as biological control agents on *Halyomorpha halys*. As a result of their experiments, they reported that the competition between the two species in terms of biological control creates negative results, that is, a disadvantage. In these studies, species, conditions, etc. Although different, they are similar in terms of the results of interspecies competition in our experiment.

Competition between two parasitoid species living in the same area; it has a significant impact on the population status and shaping of that region [58]. In biological control against pests in such regions, competition among parasitoids may affect the chance of success. It is also reported to be generally reduced. In addition, competition is important in terms of biological diversity [57,59]. In Kıvan and Aysal [55], in order to choose the right dominant species in biological control; stated that it is necessary to study the competition between species in local parasitoid species. In this context, considering our study and the literature, *T. semistratus* was found to be successful in competition. For this reason, it is important to protect *T. semistratus* in areas where it is found. In addition, it should be preferred primarily in the biological control of sunn pest. In addition, it is important to ensure the continuity of the existence of *T. turesis* in terms of the protection of biological diversity.

CONCLUSION

When two packs of sunn pest eggs were given to one *T. semistriatus* and one *T. turesis* female each, that is, when the competition was high, *T. semistriatus* became the dominant species. Two species were included in the same importance group in the experiments in which the adult emergence was followed on four packages of eggs. However, the adult emergence rate of *T. semistriatus* was found to be higher. When eight packs of eggs were given, the adult emergence rate of *T. turesis* was slightly higher than the adult emergence rate of *T. semistriatus*.

In experiments in which three *T. semistriatus* and one *T. turesis* females were investigated on sunn pest eggs, *T. semistriatus* had an average adult emergence rate of 72,40%. This rate constituted 81,83% of the total adult emergence. In three *T. turesis* and

one *T. semistriatus* experiments, the adult emergence rate of *T. turesis* was calculated as 55,65%. This rate constitutes 65,73% of the total adult emergence.

In the experiments in which the adult emergences of two parasitoids were compared one-to-one and one-to-three, it was concluded that *T. semistriatus* was more successful in competition than *T. turesis* in terms of adult emergence rate.

As a result of these results, it is thought that it would be more appropriate to prefer *T. semistriatus* over *T. turesis* in terms of use in biological control of sunn pest or mass production. In addition, it is necessary to conduct new studies on other competitors of these species in nature. In addition that, it will be useful to determine the success of species in biological control and to conduct research on the conservation of biological diversity.

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