INTERNATIONAL JOURNAL OF MODERN AGRICULTURE AND ENVIRONMENT

VOLUME 4, ISSUE 2, 2024, 1 – 9

Print ISSN 2974-4407

Online ISSN 2974-4415

Study the influence of mating duration on the efficiency of produced *Trichogramma evanescens* (Westwood)

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Abstract

Laboratory experiments were conducted to determine the influence of mating duration lengths on the fitness of *Trichogramma evanescence* females reared on *Sitotroga cerealella* (Oliv.) eggs. Different mating duration lengths were counted, then, the mated females were released on to fresh *S. cerealella* eggs to compare their fitness components after the different mating duration lengths. Fecundity, offspring emergence percentage, produced female's ratio in progeny, longevity and the general productivity were investigated. Counted mating duration lengths were: 8, 10, 13 and 35 seconds. The least mating length was 8 seconds; while the longest counted one was 35 seconds. *Trichogramma* females mated for 35 seconds parasitized the highest numbers of the offered host eggs; they produced the highest rates of individuals comprising the highest female's percentage. Generally, the highest calculated productivity for the produced females averaged 41.81 females/ female was produced from females mated for 35 seconds, while it was reduced to 18.52 females/ female when females mated for 8 seconds.

Keywords: Mating duration lengths- efficiency- *Trichogramma evanescens*- *Sitotroga cerealella*- fitness components- sex ratio- general productivity.

Introduction

Trichogramma Westwood parasitoids (Hymenoptera: Trichogrammatidae) are the well-known bio-agents around the world (Pinto, 2006), they are the most studied, mass-reared and released widely as effective bio-agents in the biological control programs aiming at the production of safe and healthy agricultural crops free from any contamination with the chemical insecticides. *Trichogramma* parasitoids are characterized by their rapid reproduction, their adaptation to weather changes, the ease and flexibility in their mass rearing (Bueno & Van Lenteren, 2010 and Consoli *et a*l. 2010), also their obvious effectiveness against many lepidopteron pests after their release in fields (Altoe *et al*. 2012 and Paraiso *et al*. 2012). As it is known, that insects including parasitoids show a diversity of reproductive strategies which considered the major factors in their life history from which; the mating process (Thornhill & Alcock 1983), and as the quality of

Print ISSN 2974-4407

Online ISSN 2974-4415

mass-reared *Trichogramma* parasitoids is vital, so, quality trials of mass-reared *Trichogramma* parasitoids should be investigated aiming at their improvement as frequently as possible (Garcia-Gonzalez *et al*. 2005), the improvement includes: the inspection and evaluation of the reproduction strategy of *Trichogramma* parasitoids mainly, the mating process. The International Organization for Biological Control suggested measuring standers including; the fitness components correlated to female's performance, sex ratio, female longevity and total fecundity (Van-Lentern 2003 and Van-Lentern *et al*. 2003). The importance of *Trichogramma* parasitoids which represented in their availability and their obvious effectiveness and success in controlling many lepidopteron pests as biological control agents, makes needs for the precise observation for the time needed to complete the mating process as it is a vital and novel point in the reproduction strategy, to determine and evaluate the impacts could be occurred on the efficiency of produced females after that mating lengths. The author predicted that the mating duration for *T. evanescens* females differ in its lengths, that prediction refers to the observations gained during the successive mass-rearing process of *T. evanescens* parasitoids around the year, also, the multiple mating times which cause females gaining material benefits as described by (Jacob and Boivin 2005), the author expected differences in the fitness components could be occurred as a result of the variations in the mating duration lengths. If nutritional resources are transferred from male to female, so, an increase in *Trichogramma* female's fitness components and their general productivity could recorded due to the lengths of the mating process. The efficiency of *Trichogramma* parasitoid is affected by many factors such as adult feeding, density, host availability, males' deficiency; mate choice, sexual selection, multiple mating which is considered the vital and necessary factors, in addition to the environmental changes and traces of natural and chemical insecticides. Although the above mentioned factors were evaluated and discussed in many works as those of (Li *et al*. 1993; Doyon and Boivin 2005; Doyon and Boivin 2006; Pratissoli *et al*. 2009; Depuech *et al*. 2010; Hatami and Karimi 2010; Zipporah *et al*. 2013; Gonzalez *et al*. 2014; Siam *et al*. 2014; Wang *et al*. 2016; Siam 2017; Siam *et al*. 2019; Tabebordbar *et al*. 2021 and Siam & El-Genaidy 2021) who assessed the impacts of that factors on the fitness of *Trichogramma* females, but the mating lengths and its effects on the efficiency and quality of produced *Trichogramma* females still rare in its references. Therefore, this work was designed to detect the mating lengths precisely then, evaluating of the impacts of those spans on the fitness components of resulting *T. evanescens* females as a parameter in their quality aiming at the sustainable production of high quality parasitoids acting well in the fields.

INTERNATIONAL JOURNAL OF MODERN AGRICULTURE AND ENVIRONMENT

VOLUME 4, ISSUE 2, 2024, 1 – 9

Print ISSN 2974-4407

Online ISSN 2974-4415

Materials and Methods

Experiments were conducted at Fayoum Laboratory for *Trichogramma* parasitoid mass rearing, Plant Protection Research Institute, Agricultural Research Center, Egypt. All trials were conducted at 25±2° C. 70±5% R.H., and the photo period of 14: 10 (L: D).

Sitotroga cerealella (Oliv.) rearing

S. cerealella was the host of *T. evanescens* and its rearing was accomplished on soft wheat as modified by Hassan (1995).

Trichogramma evanescens mass-rearing

Trichogramma parasitoid was reared as described by Abd-El Hafez (1999) on *S. cerealella* eggs which glued to self-adhesive cards and exposed to *T. evanescens* adults in transparent jars provided with a droplet of honey as a nutritive source, covered with cloth-wrapped kept by rubber band. The eggs cards were replaced daily to prevent super-parasitoidism phenomena.

Experimental Techniques

This experiment was conducted to investigate if mating duration of *T. evanescens* had a fixed time or it could vary for different spans, after that, evaluation for the impacts of those lengths on the efficiency of produced Trichogrammatids is carried out. In this experiment, four groups with three replicates, each comprises about 30 couples of newly hatched *T. evanescens* males and virgin females were individualized and put in separate test tubes, each couple was put per each test tube and provided with honey droplet for feeding, the couples were watched thoroughly during mating process which was counted using stop watch to detect the accurate mating span. After counting the lengths of mating durations, the mated females were separated. About 30 mated females from each tested mating length with three replicates per each were individualized in rearing vials and exposed to a piece of paper containing fresh *S. cerealella* eggs, the vials was provided with a droplet of honey for feeding. Control groups were newly hatched females from parents with no count for their mating duration. Daily inspection was done to detect longevity of *Trichogramma* females; parasitized eggs were counted and considered as female's fecundity. The percentage of emerged adults and females ratio in progeny was counted after emergence. Finally, the general productivity (GP) was calculated according to the formula of Tshernyshev and Afonina (1995), where;

$$\mathrm{GP} = (\text{Rate of emergence} \times \text{Rate of females in progeny} \times \text{Fecundity})$$

Obtained data was processed using Descriptive Analysis (frequency) and Analysis of Variance (ANOVA). Separation of means was accomplished by Duncan's Multiple Range Test (Duncan, 1955).

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Results and Discussion

Detecting the mating lengths:

Data presented in Figure 1, reveals that, the counted mating lengths were; 8, 10, 13 and 35 seconds. The longest counted mating span was 35 seconds which was indicated by 44.0% of the sample, followed by the span 13 seconds which was indicated by 26.0%. While the 10 seconds mating duration length was indicated by 13.0% and the shortest mating span was 8 seconds and it was represented by 17.0%.

Influence of mating lengths on the fecundity of *T. evanescens* females:

The fecundity of *T. evanescens* females was significantly differed among the different mating lengths ($P<0.05$) ($F= 557.5$). Females mated for 8 seconds parasitized the lowest number of *Sitotroga* eggs, recorded the lowest fecundity with the mean value of 36.35±.13 parasitized eggs. Results showed that, 10 seconds mating length raised the fecundity of *T. evanescens* females to 41.50±.14 parasitized eggs. The highest fecundity was induced when parasitoids female mated for 35 seconds reaching 57.0±.15 parasitized eggs, followed by those mated for 13 seconds averaged 43.7±.24 parasitized eggs, whereas control females averaged 43.50±0.64 parasitized eggs (Table 1.)

Influence of mating lengths on the percentage of adults emergence:

Compared to the controls which recorded offspring percentage with the mean value of 85.1±.23%, the lowest rate was 84.15±.15% which emerged from mated females for 8 seconds ($F= 917.04$). Elongation in the mating span to 10 seconds caused offspring emergence percentage of 90.40±.11%. Among the treatments, the highest percentage of emergence was recorded with females mated for 35 seconds with the average of 95.70±.13%, followed by those emerged from females mated for 13 seconds which resulted in 92.25±.16% (Table 1.)

Influence of mating lengths on the females longevity:

Control females lived significantly the longest days with the mean of 3.55±.11 days ($P,0.05$) ($F=7.97$), followed by those mated for 35 seconds with the mean average of 3.70±.11 days, while the two tested mating spans of 13 and 10 seconds had nearly close life span with the average of 3.15±.08 for both spans (Table 1.)

Influence of mating lengths on produced female's ratio in progeny:

The highest rate of produced females in progeny reached 76.65±.13%; it was produced as a result of mating span of 35 seconds ($F=2212.13$). However the lowest percentage averaged 60.55±.14% was produced when parents mated for 8 seconds. Parent females produced 67.25±.09% females in progeny when they mated for 10 seconds which was nearly close to those in controls which produced 67.50±.14% of females in progeny. Meanwhile, the mating span of 13 seconds recorded 70.45±.11% of females in progeny (Table 1.)

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Influence of mating lengths on the general productivity (GP):

The highest calculated general productivity was gained from females emerged after mating duration of 35 seconds as it recorded 41.81 females / female, followed by those mated for 13 seconds with the average of 28.40 females / female and 25.23 females / female after mating span of 10 seconds, while the general productivity was drastically reduced to 18.52 females / female with females resulting after 8 seconds mating interval comparing with control females which produced 24.99 females / female (Figure 2.)

In this study, the obtained results revealed that, the tested pairs of *T. evanescens* mated for different lengths; 8, 10, 13 and 35 seconds, those spans showed impacts on the efficiency of produced *T. evanescens* females. The present study showed that as the mating span increased the highest fecundity with the highest rates of emerged adults comprising high rates of females recorded, so, the different counted mating lengths could explore the idea that it could serve as a tool for the improvement of the quality of produced *T. evanescens* parasitoids. Present results could help the breeders and insectaries of *Trichogramma* parasitoids to choose factors and select items which help *Trichogramma* females to be mated for the longest span thus gaining benefits from males, the matter could help in increasing the females' fecundity resulting in improving their general productivity. Also, the obtained results could explain the variations in parasitoidism degrees found in offered host eggs, i.e. full parasitoidism could happened successfully and sometimes it failed or happened with very low rates, the matter might be referred to the mating duration lengths. The author herself is interested in mass-rearing and improvement of *T. evanescens* parasitoids for the biological control programs purposes, which demands the production of huge population with high quality parasitoids acting well in the fields. So, the sustainable mass-rearing process of *T. evanescens* parasitoids must be established with consideration of any notification could help in the sustainable production of efficient Trichogrammatids, that includes; evaluation of the impacts of availability of the host eggs with changing it periodically, the nutrition source as feeding as mentioned by Siam *et al*. (2014). The density of both the host eggs or the density of the parasitoid, presence or absence of males, fresh host eggs, laboratory rearing conditions and cold storage of rearing host eggs (Siam 2017 and Siam *et al*. 2019), even the hardness conditions which assuring production of more tolerant parasitoids (Siam 2023). The mating process in *Trichogramma* parasitoids is a vital point in their production strategy; many papers discuss the evaluation of mating process on the efficiency of the parasitoids in the point of frequent mating, mating choice, the age of females as those of (Leatemia *et al*. 1995; Jacob & Boivin 2001; Roitberg *et al*. 2001; Jacob & Boivin 2002; Ellers & Jervis 2003; Henter 2004; Jacob 2004; Martel & Boivin 2004 a and b) whom

Print ISSN 2974-4407

Online ISSN 2974-4415

discussed the effects of that factors on the efficiency of resulting females, but the present work has the novelty as rare works discussed the length of *T. evanescens* mating and its impacts on the efficacy of resulting females. According to the obtained results, mating durations differed in its lengths, and those spans had affected the fitness components of the resulting *T. evanescens* females which in my opinion could explain certain notifications could be observed during mass-rearing process of the parasitoid.

Conclusion and Recommendations

Obtained results revealed that *T. evanescens* had different mating lengths and those spans affected the fitness components and the general productivities of resulting *Trichogramma* females. So, it is recommended mainly under laboratory conditions to choose factors helping the parasitoids to mate for the longest time thus improving the efficacy of resulting parasitoids to assure sustainable production of high quality parasitoids.

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INTERNATIONAL JOURNAL OF MODERN AGRICULTURE AND ENVIRONMENT

VOLUME 4, ISSUE 2, 2024, 1 – 9

Print ISSN 2974-4407

Online ISSN 2974-4415

Tables and Figures

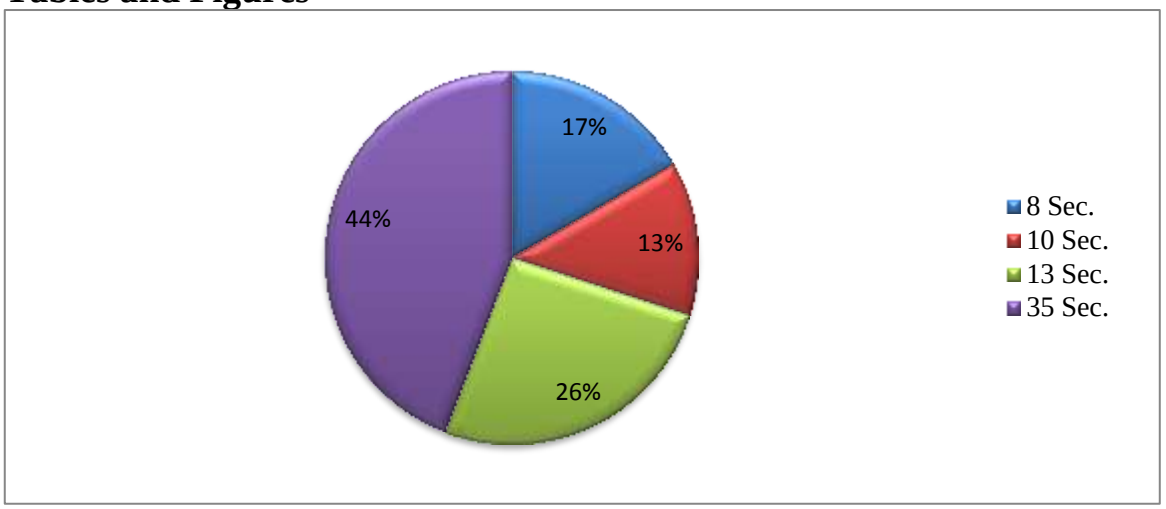

Fig. (1): Detecting the mating duration lengths of *Trichogramma evanescens* under laboratory conditions.

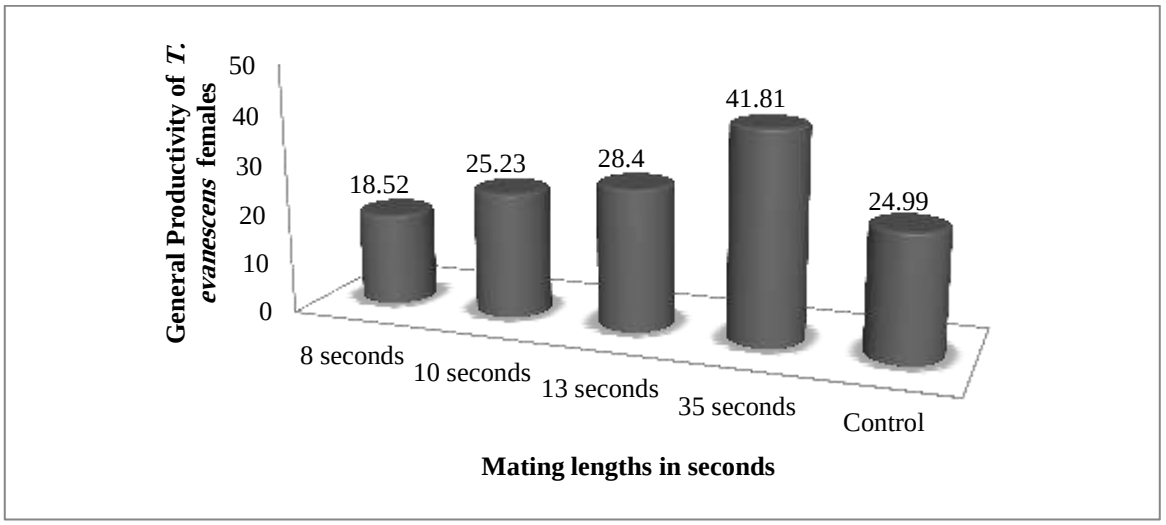

Fig. (2): General productivity (GP) of *Trichogramma evanescens* females produced after different mating lengths.

Table (1): Influence of counted mating lengths on the efficacy of *Trichogramma evanescens* females under laboratory conditions.

Mating Lengths	Fecundity (parasitized eggs/female)	% adults emergence	Female longevity(days)	%Females
8 Seconds	36.35^{d}±.13	84.15^{e}±.15	3.15^{c}±.08	60.55^{e}±.14
10 Seconds	41.5^{c}±.14	90.4^{c}±.11	3.15^{c}±.08	67.25^{d}±.09
13 Seconds	43.7^{b}±.24	92.25^{b}±.16	3.15^{c}±.08	70.45^{b}±.11
35 Seconds	57.0^{a}±.15	95.7^{a}±.13	3.7^{a}±.11	76.65^{a}±.133
Control	43.5^{b}±.64	85.1^{d}±.23	3.55^{b}±.11	67.5^{c}±.14

Means followed by the same letter, in the same column, are not significantly different. (Duncan 1955)