Effectiveness of Some Natural Enemies in Limiting the Spread of Fall Armyworm, *Spodoptera frugiperda*

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Abstract

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The field work of this study was carried out in corn fields in Hama governorate and the laboratory work was carried out in Hama Center for Rearing Natural Enemies (HCRNE). This study aimed to evaluate the effectiveness of the egg parasitoid *Trichogramma principium* and larval parasitoid *Bracon hebetor* in the control of fall armyworm (FAW), *Spodoptera frugiperda* (JE Smith) (Lepidoptera: Noctuidae). The rates of parasitism on FAW eggs ranged from 25 to 50%. It was found that there was an inverse relationship between the increase in the number of eggs per batch and the rate of parasitism. The study also showed that the parasitoid *Bracoon hebetor* parasitized the fourth, fifth, and sixth larva instars in varying proportions, and the parasitism rate ranged from 10 to 80%.

Keywords: Corn, natural enemies, fall armyworm, Syria.

Introduction

The fall armyworm, *Spodoptera frugiperda* (JE Smith) (Lepidoptera: Noctuidae) is one of the most important insect pests of cereal crops, especially maize (*Zea* spp.). Other crops attacked by this insect include 353 plant species from 76 plant families, mainly Poaceae, Asteraceae and Fabaceae (Andrews *et al*., 1980; Goergen *et al*., 2016; Wu *et al*., 2021). The insect spreads in most areas of corn cultivation in the world, such as Africa, Asia and some parts of Europe (Early *et al*., 2018).

Fall armyworm (FAW) was reported in Daraa Governorate, Syria since the beginning of November 2020 after it was reported in the neighboring countries, Jordan and Palestine. In addition to its ability to spread, reproductive capacity, entry via seed and the availability of cultivated host plants, FAW has become a major threat to agriculture in Syria and may cause significant crop loss (Mohammed, 2022). Young leaves, ears, and tassels are the preferred plant parts by the pest resulting in significant loss in the maize crop (De-Almeida *et al*., 2002). FAW travels approximately 500 km before starting oviposition (Prasanna, 2018). The economic impact of fall armyworm on agricultural productivity across Africa are significant, and in the absence of appropriate control methods, it is estimated that losses caused by FAW in the maize crop could range from 8.3 to 20.6 million metric tons per year in only the 12 maize-producing countries in Africa (McCullars, 2019). Studies conducted on this insect pest showed that the strategy to control it in corn fields focused on the use of chemical pesticides (Hardke *et al*. 2011; Yu *et al*, 2003). Focusing and relying on chemical control is not only costly for the farmer and economically unsustainable for farmers who lack resources poses a threat to human health, can cause environmental pollution, in addition to the emergence of pest strains resistant to pesticides (Yu, 1991). Frequent and improper use of pesticides impairs the effectiveness of other integrated pest management measures in maize cropping systems (Teixeira & Andaloro, 2013). Parasitoids and predators can be better employed to manage *S. frugiperda* by increasing the augmentation or conservation of natural enemies already present in the target environment (Van Driesche *et al*., 1996).

Given the importance of biological control in limiting the spread of this insect and the damage it causes, this study aimed to evaluate the effectiveness of some biological enemies in limiting the spread of FAW, *Spodoptera frugiperda*.

Materials and Methods

The field work was carried out in corn fields in Hama governorate, and the laboratory work was carried out in Hama Center for Rearing Natural Enemies (HCRNE).

Collecting of FAW eggs and larvae

Samples were collected through periodic field visits to fields planted with the maize crop. The pest egg patches were collected with part of the leaf that carries them, placed in plastic or glass jars covered with muslin cloth, placed in cool containers and transported directly to the laboratory.

FAW larvae were also collected from infested maize plants by collecting the entire infested plant, transferred to the laboratory in cool containers and examined. Fresh corn leaves were added daily.

Rearing FAW in the laboratory

The FAW eggs were incubated at a temperature of 25°C, 16:8 hours (light:dark) photoperiod, and a relative humidity of

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60%. Upon hatching, the larvae were distributed individually in jars or glass tubes and fed on the natural host (corn plant leaves) regularly, until the completion of all life stages until they reach the adult stage. Adults were placed in a special cage for mating, and provided with corn plant leaves to lay eggs on. Eggs were collected on a daily basis, and used later in parasitism and predation tests.

Mass rearing and production of *Trichogramma principium* parasitoids

Each egg mass was placed in a glass tube measuring 20×2.5 cm with the addition of a drop of honey on the inner edges of the tube, covered with cotton and placed at a temperature of 25±1°C, relative humidity of 70±5%, photoperiod of 8:16 hours (dark:light).

Mass rearing of *Trichogramma principium*

The mass rearing of *Trichogramma principium* was carried out on flour moth, *Ephestia kuehniella* (Zeller, 1879) eggs, according to the steps shown in Figure 1.

Mass rearing and production of the parasitoid *Bracon hebetor*

Three males and six females were placed in each glass tubes or plastic jars together with 50 larvae of *Ephestia kuehniella* and provided with appropriate nutrition and incubated under the same conditions as mentioned above.

Evaluation of the efficacy of the parasitoid *Trichogramma principium* on parasitizing fall armyworm eggs

A carton slide containing 50 parasitized pupae was placed one day before the emergence of adults with one fresh egg masse placed inside a glass tube with appropriate amount of honey, covered with a cotton roll, and incubated at 25±1°C temperature, 70±5% relative humidity, and 12:12 hours (light:dark) photoperiod. After 48 hours, the egg mass was transferred to another tube, and parasitism rate data was recorded in terms of the distinctive exit holes and the number of emerging parasitoids. Parasitism ratio was calculated according to the following formula:

$$\text{Parasitism\%} = \frac{\text{No. of parasitized eggs}}{\text{No. of total egg collected}} \times 100$$

Evaluation of the efficacy of the parasitoid *Bracon hebetor* on parasitizing fall armyworm larvae

The experiment targeted the fourth, fifth, and sixth instars larvae, where ten larvae of similar age were placed inside a plastic jar with a capacity of half kg, with continuous feeding with maize leaves. Three males and three females were added to each jar, and the jars were covered with a muslin cloth with a little honey to feed the parasitoid adults.

Parasitism ratio was calculated according to the following formula (Abd Elmageed *et al*., 2021):

$$\text{Parasitism\%} = \frac{\text{No. of parasitized larva}}{\text{No. of total larva collected}} \times 100$$

Figure 1. Steps of rearing parasitoid *Trichogramma principium* in the laboratory. (A): spreading eggs on cardboard painted with gum Arabic, (B): cardboard divided into strips, (C): egg strips placed inside glass jars containing newly emerged parasitoids, (D): parasitism is completed and the parasitized insect eggs are turned into pupae, (E): cutting the strips and filling them into release capsules.

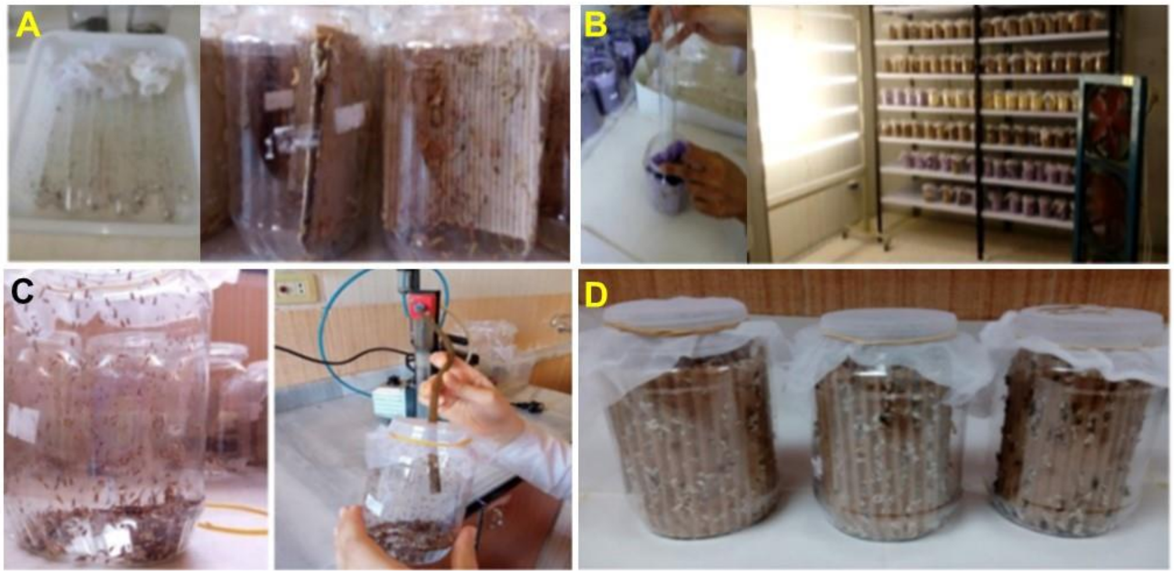

Figure 2. Steps of rearing the parasitoid *Bracon hebetor* in the laboratory. (A): jars containing flour moth larvae, (B): providing the rearing unit with the parasitoid, (C): pupation of the parasitoid, (D): collection of parasitoids after exiting from pupae.

Data analysis
Significance between treatments was ditermined by one-way analyses of variance (ANOVAs), followed by a Tukey's test for multiple comparisons at P=0.05 (SPSS, 2007).

Results and Discussion

Efficiency of the parasitoid *Trichogramma principium* in parasitizing FAW eggs
The parasitism rate on FAW eggs ranged between 25 to 50%. Through this preliminary experiment, it was found that there was an inverse relationship between the increase in the number of eggs per one bite and parasitism rate. The higher the number of eggs, the lower the parasitism rate. Often the eggs are laid in multiple layers, which hinders the intruder's access. It was found that the density of scales covering the egg batch leads to a low parasitism rate compared to the batches with fewer scales. The results showed that the correlation coefficient between the number of eggs and the parasitism rate was strongly negative (r= - 0.929).

Figure 3 shows the difference in the number of eggs and, accordingly, the parasitism rate based on the number of eggs in the different batches, where the highest parasitism rate was 50% on an egg batch of 50 eggs, 40% on a batch of 57 eggs, 35% on a batch of 100 eggs, 33% on a batch of 150 eggs and finally 25% on a batch of 200 eggs. Increasing the number of eggs in one hatching led to a decrease in the number of eggs parasitized, and thus the parasitism rate. Figure 4 shows that there was statistical differences between the parasitism rate on the 50 eggs patch compared to other egg patches. There were no statistical differences in the parasitism rates on the egg masses of 75, 100 and 150 eggs, and also in the parasitism rate between the two egg masses 150 and 200 eggs.

The difference in the number of eggs in different egg masses led to a difference in the thickness of the scale layers of egg masses, as the thickness of the shell increased with the increase in the number of eggs in one egg mass, and this led to a decrease in parasitism rates when the number of eggs in the egg masse increased as shown in Figure 4, and this is consistent with a prevoius study (Hou *et al*., 2022) which indicated that egg masses of *S. frugiperda* are covered with scale layers and the various scale layer thicknesses of these masses can affect parasitoids efficiency.

Agboyi *et al.* (2020) pointed out that *Trichogramma* wasps are among the best options for potential development of biological control programs targeting FAW eggs. Although FAW egg mass scale thickness could lower *Trichogramma principium* parasitoid performance on this host (Hou *et al*., 2022).

In America, *Trichogramma principium* parasitoids have been used to efficiently control the eggs of *S. frugiperda* (Soares *et al*., 2012). Area-wide releases are made at tactical points (ranging from 20 to 40 per hectare) in 3-day intervals to obtain a constant presence of adult wasps for achieving proactive egg parasitism (Cruz *et al*., 2016). This improved system is employed early in the season to limit the season-long spread of FAW (Agboyi, 2020).

Efficiency of the parasitoid *Bracon hebetor* in parasitizing FAW larvae
The study showed that the parasitoid *Bracoon hebetor* parasitized the fourth, fifth, and sixth larva instars in varying proportions, as in Figure 4. As it preferred the fourth larva instar with a parasitism rate that ranged from 50 to 80%, the fifth larva instar with a parasitism rate that ranged between 40 to 70%, and the sixth larva instar with a rate that ranged between 10 to 30%.

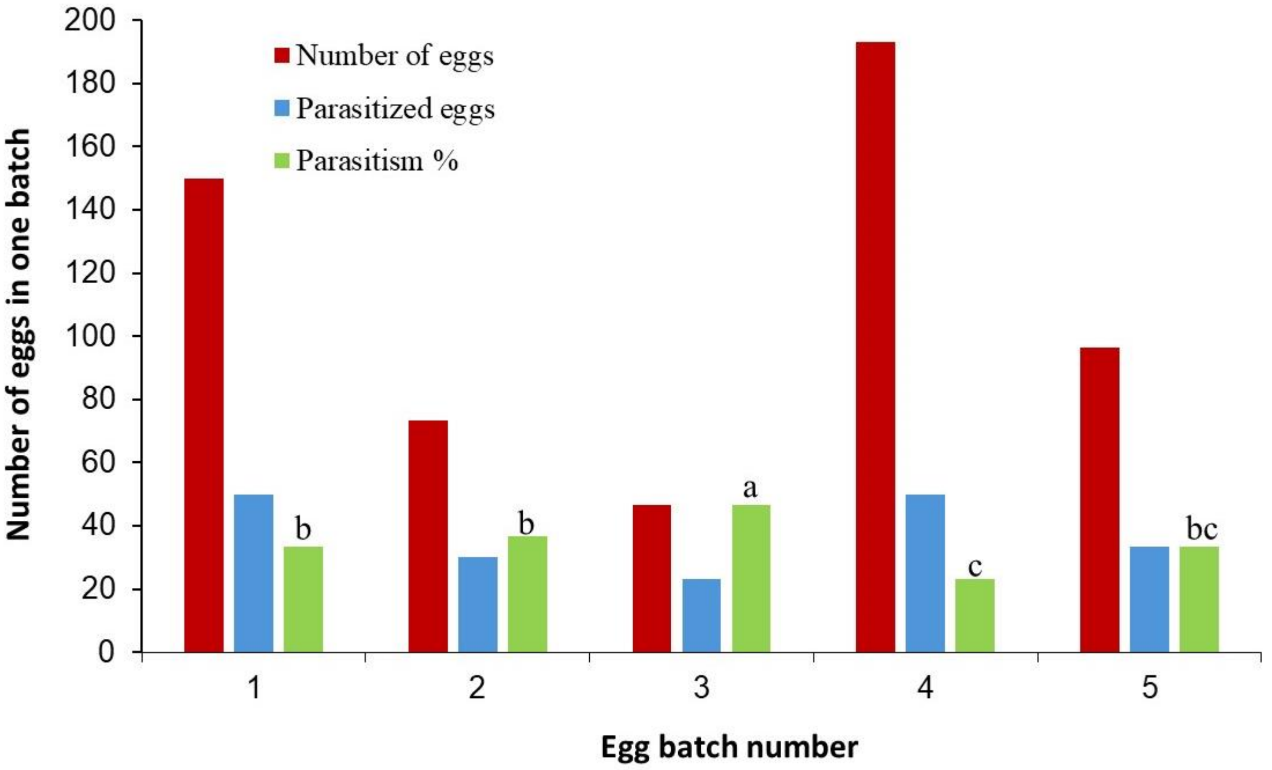

Figure 3. *Trichogramma principium* parasitism rate on fall armyworm eggs. Bars representing parasitism rate marked with the same letters are not significantly different at P=0.05.

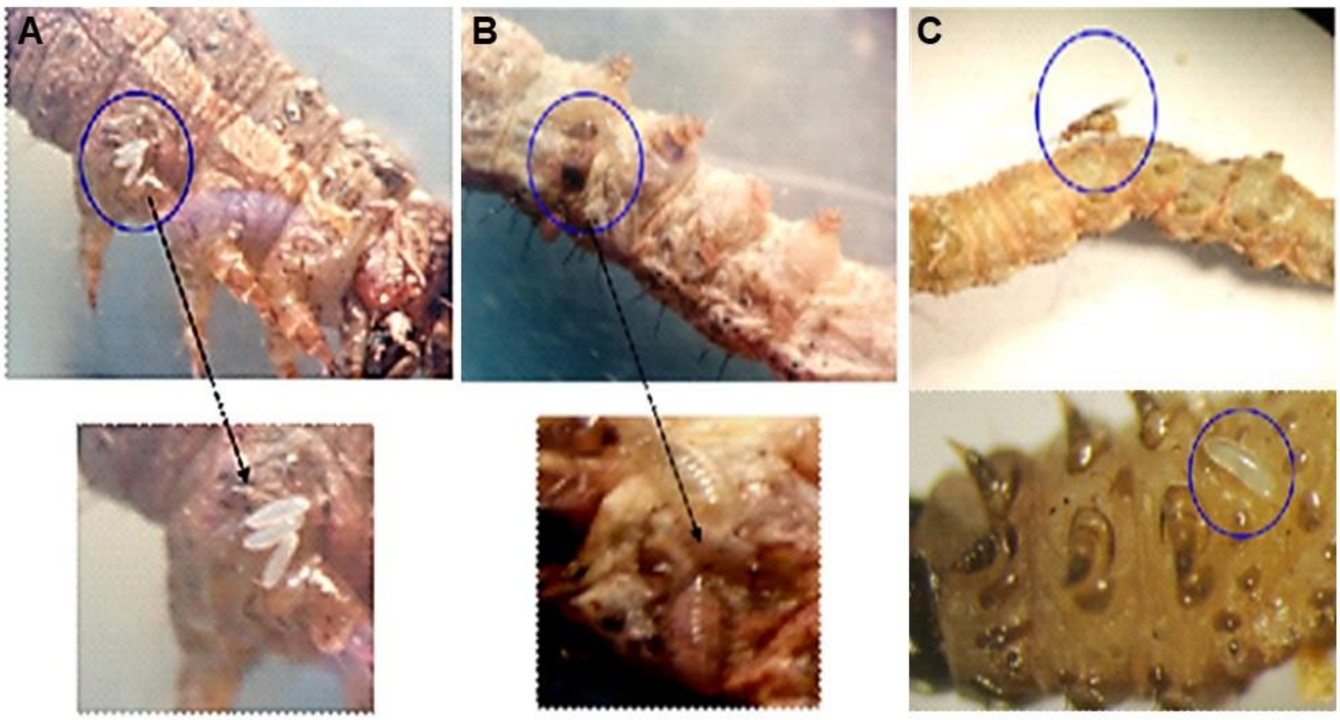

Figure 4. Different stages of the parasitoid *Bracon hebetor* on fall armyworm larvae. (A): parasite eggs, (B): parasite larva, (C): Parasitoid female laying eggs.

The number of parasitized fourth-instar larvae was 8, 7, 5, 8 and 6 with parasitism percentages of 80, 70, 50, 80 and 60% in the first, second, third, fourth, and fifth replicates, respectively. The number of parasitized fifth-instar larvae was 6, 6, and 5. and 4 and 7 with parasitism percentages of 60, 60, 50, 40 and 70% in the first, second, third, fourth and fifth replicates, respectively, while the number of parasitized larvae from the sixth age was 3, 2, 3, 1 and 2, with parasitism percentages of 30 and 20%. 30, 10 and 20% in the first, second, third, fourth and fifth replications, respectively (Figure 5). In general, the average parasitism rate on the fourth instar in the five replicates was 68, 56% on the fifth instar, and 22% on the sixth instar, meaning that the fourth larval age of the insect is the preferred age for the parasitoid, as statistical analysis showed that there was a significant difference in the average parasitism rates between the fourth and fifth instars, with the sixth instar of the larvae at the 1% level.

Different letters indicate a significant difference in the rates of parasitism on the larval stages of the armyworm insect at a significant level of 5%. Latha *et al*. (2019) pointed out that *B. hebetor* was an effective parasitoid of the invasive pest *S. frugiperda* and further needs to be tested for its efficacy under field conditions. If it proves as an effective biological control agent of *S. frugiperda* under field conditions.

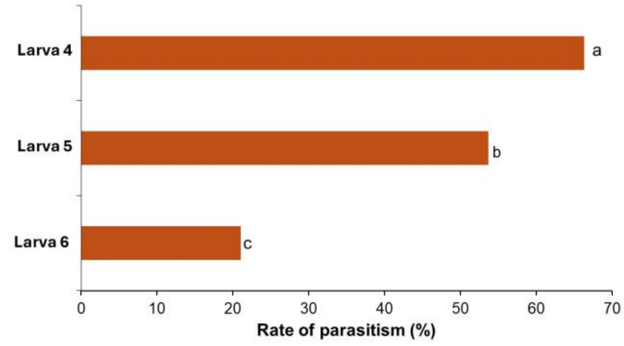

Figure 5. Parasitism rate by *Bracon hebetor* on different larval instars of FAW. Bars marked with different letters are significantly different at P=0.05.

الملخص

بشير، عبد النبي محمد، إياد محمد محمد، شادي محمد سليمان وميس أحمد نعوف. 2024. دراسة فعالية بعض الأعداء الحيوية في الحدّ من انتشار دودة الحشد الخريفية (*Spodoptera frugiperda*). مجلة وقاية النبات العربية، 42(3): 349-354.

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نفّذ العمل الحقلي في حقول الذرة في محافظة حماه، وتمّ تنفيذ العمل المختبري في مركز حماه لتربية الأعداء الحيوية (HCRNE). هدف هذا البحث إلى دراسة فعالية متطفل البيض *Trichogramma principium* ومتطفل اليرقات *Bracon hebetor* على دودة الحشد الخريفية (*Spodoptera frugiperda* JE Smith) (Lepidoptera: Noctuidae). تراوحت معدلات التطفل على بيض دودة الحشد الخريفية بين 25 إلى 50%. كما تبيّن وجود علاقة عكسية بين زيادة عدد البيض في لطعة البيض ومعدل التطفل. أظهرت الدراسة أن المتطفل *Bracoon hebetor* هو متطفل خارجي على الأعمار اليرقية الرابع والخامس والسادس ليرقات الحشرة وبنسب متفاوتة، وتراوحت نسبة التطفل من 10 إلى 80%.

كلمات مفتاحية: ذرة، أعداء حيوية، دودة الحشد الخريفية، سورية.

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