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# ASSESSMENT TOXICITY OF RECOGNIZED INSECTICIDES AGAINST *Pectinophora gossypiella* (SAUNDERS) AND THEIR IMPACT ADVERSE ON DEVELOPMENT AND REPRODUCTIVE PERFORMANCE OF *Bracon brevicornis* (WESMAEL) (HYMENOPTERA: BRACONIDAE)

**RANIA M. EL-SHENNAWY [a*] AND MERVAT A. A. KANDIL [a]**

[a] Department of Cotton Bollworms Research, Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt.

**AUTHORS' CONTRIBUTIONS**

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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## ABSTRACT

In the current work, the toxicity of three compounds(belong to three different insecticidal groups); Flufenoxuron, Spinetoram, and Lambda-cyhalothrin were evaluated against the newly hatched larvae of *Pectinophora gossypiella* to estimate the $LC_{50}$ values, in addition to study the adverse effects on some biological parameters of the insect and its larval parasitoid *Bracon brevicornis*. According to $LC_{50}$ values, Lambda-cyhalothrin was the highest potency and the most toxic (0.358) followed by spinetoram (2.62) and Flufenoxuron (4.312). Moreover, all tested compounds significantly increased *P. gossypiella* larval duration to 23.5, 19.0, and 21.4 days/larvae for Lambda-cyhalothrin, Spinetoram, and Flufenoxuron, respectively, compared to 15.3 days for control. In addition, the highest percentage of total larval mortality was recorded (71%) for Flufenoxuron followed by (67%) for Lambda-cyhalothrin then (57%) for Spinetoram, compared to (4%) for untreated. Besides, percent of (5, 10, and 8 %) of pupal mortality were recorded for previously mentioned three tested compounds, respectively. Furthermore, rearing *B. brevicornis* on the full-grown host of *P. gossypiella* resulted from Flufenoxuron, Spinetoram, and Lambda-cyhalothrin treatments cussed significant elongations of both larval and cocoon durations recorded 10.9, 9.8, and 11.9 days/ larvae, and 8.3, 7.6, and 6.6 days/ cocoon, respectively, compared with 7.3 days/ larva and 5.6days/ cocoon in control. Therefore, the total immature period of the parasitoid *B. brevicornis* was observed to increase as a result of treatments. Besides, some biological parameters of *B. brevicornis* adults were also affected whereas, the oviposition periods were reduced to 9.6, 8.3, and days in rearing parasitoid females on Flufenoxuron, Spinetoram, and Lambda-cyhalothrin treated larvae, respectively, compared to 12.3 days for control, at the same time, the total number of deposited eggs by parasitoid females were reduced to 132.0, 109, and 74.3 eggs/ female, for Flufenoxuron, Spinetoram, and Lambda-cyhalothrin treatments, respectively, compared to 197.0 eggs/ untreated females.

**Keywords:** *Pectinophora gossypiella*; *Bracon brevicornis*; flufenoxuron; spinetoram and lambda-cyhalothrin; toxicity and biology.

**Corresponding author: Email: Dr.mervatkandel@yahoo.com;*

## 1. INTRODUCTION

Cotton is considered the most important industrial crop worldwide. It varieties different high significantly among themselves concerning the infestation of different insect pests**.**

In Egypt, a very high rate of infestation by (PBW), *Pectinophora gossypiella* (Saunder**s**) (Lepidoptera: Gelechiidae) on cotton has been reported more than 100 years ago [1] and is still considered as one of the most important worldwide spread pests of cotton [2]. It causes serious damage in cotton bolls resulting in a high reduction in quantity and quality of cotton yield. Parasitism is a biological control method that plays an important role in natural and agricultural ecosystems by influencing and regulating the population density of different pests.

The arthropod parasite (Ecto-parasitoid) *Bracon brevicornis* (Walker) (Hymenoptera: Bracondae) is a major cause of population losses in lepidopterous pests throughout the world [3]. The Parasitoids larvae attack different lepidopterous pests feeding on the host body resulting in its death, a single host provides all needed food for the whole development of the Parasitoid till an adult stage, [4-8]

Pesticides not only affect their target pests but also their effects may extend to the pest natural enemies as a side effect for their application. Some authors studied the effects of different insecticides on parasitoids and evaluate acute toxicity by determining the median lethal dose ($LD_{50}$) or concentration ($LC_{50}$) [9,10]. Different side effects of many insecticides were evaluated under the laboratory studying, exploiting compatibility of chemical and biological control methods that help minimize any negative influence on the natural enemies [11]. Kandil and Moustafa [6], studied the Impact of conventional insecticides on two bollworms and their indirect effects on some biological parameters *B. brevicornis* Lepidopteran pests represent the highest percentage of pyrethroid targeted insects, followed by Spinetoram and IGRs [12]. The side effects of pyrethroids on natural enemies report primarily to short-term mortality by directly or indirectly effect through the evaluation of the emergence of parasitoids from the different host treated [13,14,15].

Spinetoram is a biotic compound that has been used for controlling lepidopteran pests effectively. It is produced naturally from the actinomycete bacterium species called *Saccharo polyspora spinetoram* and has been registered by US Environmental Protection Agency for use in pest control, [16,17,18]. Generally, biological pesticides have less influence on natural enemies [19].

Flufenoxuron is a benzoyl phenyl urea insecticide that has been tested successfully against several species of insect pests [20, 6,8].

This study aims to investigate the toxicity of tested insecticides against Pectinophora gossypiella and their adverse effects on parasitoid B. brevicornis through the interactions between the parasitoid and its treated host.

## 2. MATERIALS AND METHODS

### 2.1 Insect Stock

#### 2.1.1 Comment host

The two larval instars used in this experiment (neonate and full-grown larvae) of Pink bollworms, *P. gossypiella* susceptible strain, were obtained from the Bollworms Research Department, PPRI. It was reared under controlled conditions (26 ± 1 °C and 75 ± 5.0% RH) on an artificial diet according to [21].

#### 2.1.2 Collecting of *Bracon brevicornis* parasitoid

The field strain larvae and cocoons of *B. brevicornis* parasites were observed associated with the full-grown larvae of *P. gossypiella* at the end of the cotton season. It was collected from cotton fields at Qaha region, El- Qaliobia Governorate, and kept under laboratory condition until parasitoid adult emergence. It reared for one generation on laboratory strain full grown larvae of pink bollworm without any insecticid to adapt the parasitoid before directing the experiment.

### 2.2 Insecticides Used

Three insecticides belonging to three different groups were tested against *P. gossypiella* larvae:

Flufenoxuron 10% DC as Benzoylurea and Spinetoram 12% SC, as a bio-insecticide and Lambda-cyhalothrin 5% EC as a synthetic pyrethroid.

### 2.3 Procedure

#### 2.3.1 Toxicity

To study the larvicidal activity of Flufenoxuron, Spinetoram and Lambda-cyhalothrin against *P. gossypiella* newly hatched larvae, serial numbers of concentrations; (6.25, 3.12, 1.56, 0.78 and 0.39 ppm) for Flufenoxuron, (12, 6, 3, 1.5, 0.75, and 0.375 ppm)

for Spinetoram and (0.315, 0.157, 0.0782, 0.039 and 0.0195ppm) for Lambda-cyhalothrin were freshly prepared in water diluted to estimate their toxicity and evaluate $LC_{25}$, $LC_{50}$, and $LC_{90}$ values for each of them against neonate larvae of *P. gossypiella*. Different (5) concentrations for each tested compound were sprayed on the surface of the artificial diet (4gm/Petri dish). Forty neonate larvae of the PBW were allowed to feed on the treated diet / each compound; three replicates / each concentration were prepared and kept under constant conditions of 26 ± 1 °C and 75 ± 5.0% RH. In addition to three replicates, each one 40 neonate larvae were allowed to feed on an untreated diet as control. After one day for Lambda-cyhalothrin and 3 days for Flufenoxuron and Spinetoram treatments, the dead larvae were counted to calculate the acute toxicity of the three tested compounds.

The percentages of larval mortality were calculated by Abbot's formula [22]. The analysis was conducted to estimate $LC_{50}$ and $LC_{90}$ values with their fiducial limits by Probit (proban) analysis software according to Finny (1971).

### 2.3.2 Determination of developmental parameters (Biology)

For determination of the direct effect of the $LC_{50}$ for Lambda-cyhalothrin, Flufenoxuron and Spinetoram on different developmental parameters; the $LC_{50}$ for each tested compound was applied on the upper surface of the diet poured in the glass tubes (2 cm × 7.5 cm). The control tubes were treated with distilled water only. Three replicates/treatments of 40 tubes were used for each compound in addition to a similar number of tubs for control. Individually, the neonate larvae of PBW were transferred to each tube using a fine hairbrush, and then all tubes were capped with cotton and kept under the previous controlled conditions in an incubator and inspected daily until pupation. Resulted Pupae were placed in clean tubes till adults' emergence. Some biological aspects such as mortalities' percentages and durations for both larvae and pupae and subsequently total immature duration were estimated.

#### *2.3.2.1 Effect of P. gossypiella treated host larvae on reared adults of parasitoid B. brevicornis*

Newly emerged adults of *B. brevicornis* parasitoid were sexed (5♀ and 5♂) immediately after emergence, and kept in glass jars (530 $cm^3$). Five individuals of full-grown larvae resulting from $LC_{50}$ treatment for each tested compound (Lambda-cyhalothrin or Flufenoxuron or Spinetoram) were offered daily to the parasitoids inside the glass jar. Each glass jar was covered with muslin cloth and inspected daily. The host larvae were exchanged daily for inspection. For each treatment, three replicates were prepared. The pre-oviposition, oviposition, and post-oviposition periods in addition to the longevity of females were recorded. Also, the number of eggs laid / female, as well as hatchability percent, were estimated.

#### *2.3.2.2 Determination of the developmental parameters of B. parasitoid*

For studies developmental parameters of the parasitoid, 60 eggs of the parasitoid (for each treatment) were collected from the treated host larvae, divided into three replicates (20 eggs/replicate), kept under 26 ± 1 °C and 75 ± 5.0% RH (controlled conditions) and detected daily. The hatchability of the eggs with an incubation period of eggs, larval and cocoon duration was recorded.

#### *2.3.2.3 Latent effect of P. gossypiella treated host larvae on resulting adults of B. brevicornis*

For each treatment three replicates (each of 5♀ + 5♂) of newly emerged adults of *B. brevicornis* individuals. It reared on full-grown larvae of *P. gossypiella* resulting from each treatment Lambda-cyhalothrin or Flufenoxuron or Spinetoram). The treated larvae were introduced daily. The daily parasitized host insects/ replicate were carefully transferred to Petri dish under the same controlled conditions. The total number of laid eggs by each female wasp (for each treatment) along its longevity was recorded. Additionally, the oviposition periods and adults' longevities were estimated. Moreover, percent hatchability and Sterility were also calculated according to Tapozada et al. [23].

**% Sterility observed = 100 – Egg hatchability percentage**

### 2.3.3 Data analysis

Analysis of variance (ANOVA) was performed using Costas program software. The toxicity index and potency levels were also calculated according to Sun's [24] equation:

***Toxicity index = ($LC_{50}$ of the most toxic compound / $LC_{50}$ of the tested compound) X 100.**

***Potency levels = $LC_{50}$ of least toxic compound / $LC_{50}$ of the tested compound.**

## 3. RESULTS

### 3.1 Direct Effects of Tested Compounds on *P. gossypiella* Treated Larvae

#### 3.1.1 Toxicity assessment

Data recorded in Table 1 indicated the $LC_{25}$, $LC_{50}$, and $LC_{90}$ values of Flufenoxuron, Spinetoram, and Lambda-cyhalothrin in treating newly hatched larvae of *P. gossypiella*. According to $LC_{50}$ values Lambda-cyhalothrin compound is considered to be the highest potency and more toxic (0.358) among other tested compounds followed by spinetoram (2.64) and Flufenoxuron (4.312), respectively.

### 3.2 Effect on Some Biological Parameters *P. gossypiella*

#### 3.2.1 Immature mortality

Under laboratory conditions of (26.0 ± 1.0 °C and 75.0 ± 5.0% RH), the effects of $LC_{50}$ values for Flufenoxuron, Spinetoram, and Lambda-cyhalothrin on PBW larval duration and mortality were studied. All tested compounds resulted in high percents of larval mortality estimated by (71%) for Flufenoxuron treatment followed by Lambda-cyhalothrin (67%) and Spinetoram (57%) compared with (4%) for the untreated check.

In contrast, Spinetoram showed the higher potency for pupal mortality percentage as it recorded 10% followed by 8 and 5% for Flufenoxuron and Lambda-cyhalothrin treatments, respectively, and compared with (2%) for the untreated check. Accordingly, the accumulated (total) mortality percent's of immature stage recorded (79, 67, and 71%) for Flufenoxuron, Spinetoram, and Lambda-cyhalothrin treatments respectively, compared with (6%) for the untreated check (Fig. 1).

#### 3.2.2 Immature duration

Data in Fig. 2 showed the effect of tested compounds on the duration of immature stages of *P. gossypiella* treated as newly hatched larvae all tested compounds; Flufenoxuron, Spinetoram, and Lambda-cyhalothrin; indicate an increase in larval duration to 23.5, 19.0, and 21.4 days/larvae for previously mentioned compounds, respectively, compared with 15.3 days in untreated check.

**Table 1. Toxicological evaluation of Flufenoxuron, Spinetoram, and Lambda-cyhalothrin compounds against pink bollworm larvae under laboratory conditions of (26.0 ± 1.0 °C and 75.0 ± 5.0% RH)**

| Treated stage | Compounds used | LC (ppm) | | | | Toxicity index / $LC_{50}$ | Potency levels / $LC_{50}$ |
|---|---|---|---|---|---|---|---|
| | | $LC_{25}$ | $LC_{50}$ | $LC_{90}$ | Slope ± SE | | |
| ***p. gossypiella* newly hatched larvae** | **Flufenoxuron** | 1.972 | 4.312 | 73.20 | 1.0 ±0.11 | 8.30 | 1 |
| | **Spinetoram** | 1.032 | 2.62 | 42.32 | 1.8 ±0.15 | 13.66 | 1.7 |
| | **Lambda-cyhalothrin** | 0.074 | 0.358 | 37.54 | 1.25 ±0.11 | 100 | 12 |

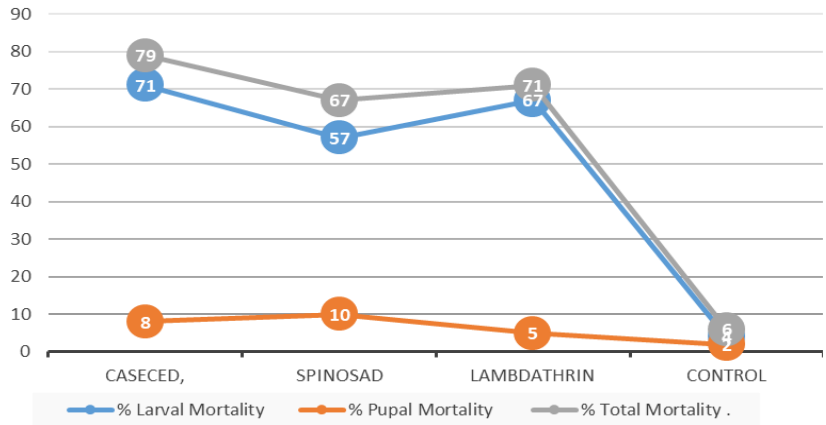


**Fig. 1. Effect of tested compounds on mortality of immature stages of *P. gossypiella* treated as newly hatched larvae**

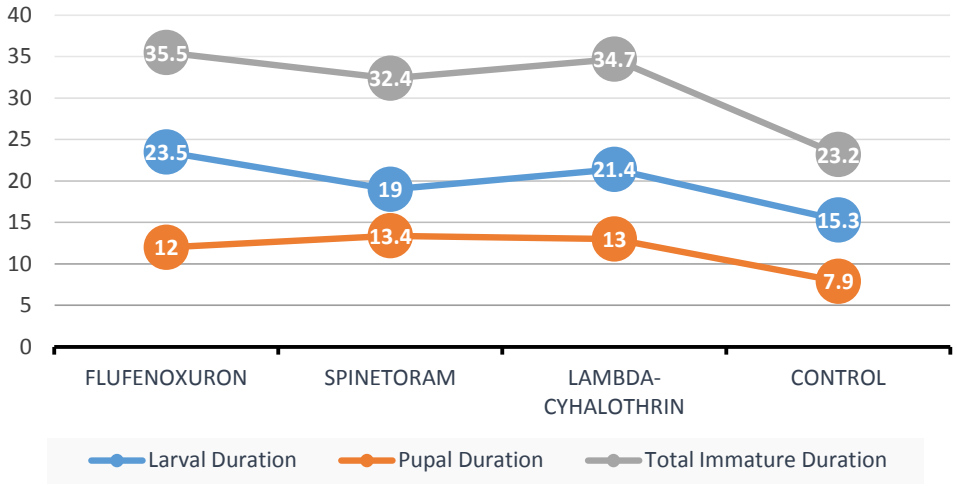


**Fig. 2. Effect of tested compounds on the duration of immature stages of *P. gossypiella* treated as newly hatched larvae**

Besides, also, treatments affect pupal duration by elongation as they recorded 12.0, 13.4, and 13.0 days/pupa for Flufenoxuron, Spinetoram, and Lambda-cyhalothrin, respectively, compared with 7.9 for control. Subsequently, the duration of total immature stages was highly elongated to reach 35.5, 32.4, and 34.7 days for previously mentioned compounds, respectively, compared with 23.2 days for the untreated check, (Fig. 2).

## 3.3 Effect of Rearing Parasitoid *B. brevicornis* Adults on *P. gossypiella* Untreated Treated Larvae

### 3.3.1 Effect on adult wasps of *B. brevicornis*

Feeding newly emerged adults of parasitoid *B. brevicornis* (resulting from untreated culture) on host larvae of *P. gossypiella* treated by $LC_{50}$ of Flufenoxuron, Spinetoram and Lambda-cyhalothrin compounds resulted in a reduction in females' longevities represented mostly in their oviposition periods that recorded (9.5, 8.6, and 11.3) for tested compounds, respectively, compared to 11.9 for control (Fig. 3).

Besides, a reduction effect on the number of deposited eggs by females was recorded (99, 104, and 116 eggs/ female) for previous compounds, respectively, compared with 163 eggs/female in untreated. In addition, a percentage of reduction was recorded in hatchability percent as a result of treatments where they recorded 87, 91, and 80% for tested compounds, respectively, compared to 97% in the control check, (Fig. 4).

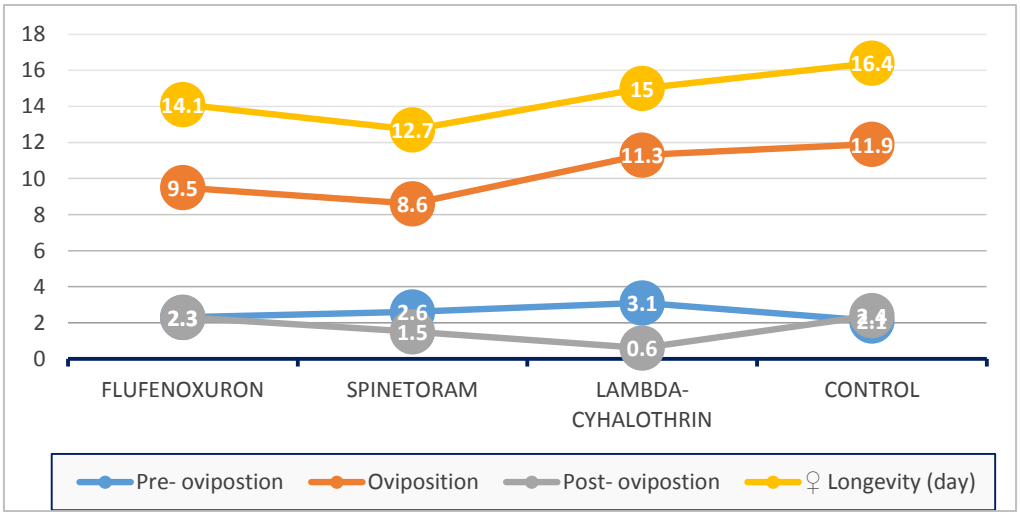


**Fig. 3. Effect of *P. gossypiella* treated larvae on untreated *B. brevicornis* adults' longevity**

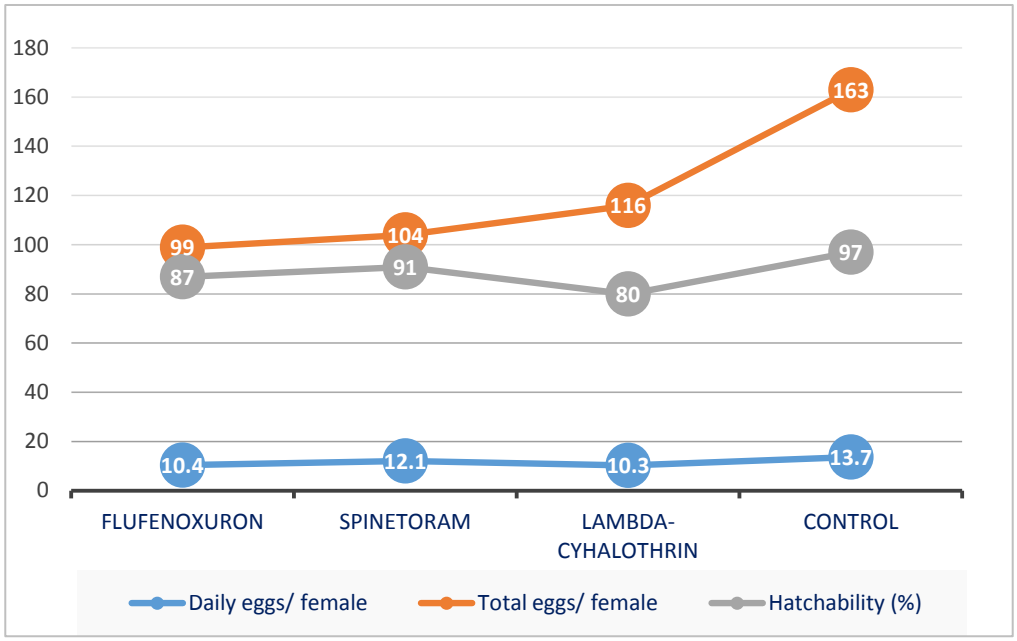


**Fig. 4. Effect of *P. gossypiella* treated larvae on *B. brevicornis* adults' reproductive potential**

### 3.3.2 Effect on resulting immature stages duration of *B. brevicornis* host treated

**Egg incubation Period:** Directly, after the parasitoid female deposited its eggs on different full-grown *P. gossypiella* host larvae treated as a neonate with the three tested compounds, Flufenoxuron, Spinetoram, and Lambda-cyhalothrin, the larvae were incubated under the constant condition of 26.0 ± 1.0 °C and 75.0 ± 5.0% RH. Represented data in (Fig. 5) indicated no significant difference in eggs incubation periods for the three tested compounds in comparison to control check, as they recorded 2.8, 2.7, and 2.9 days for previously mentioned compounds, respectively, compared to 2.7 days for control check.

**Larval and Cocoon Duration:** On the other hand, represented data in (Fig. 5) indicated significant elongation in both larval and cocoon periods required to complete their durations and therefore total immature periods of the parasitoid *B. brevicornis*, reared on full grown larvae resulted from three tested

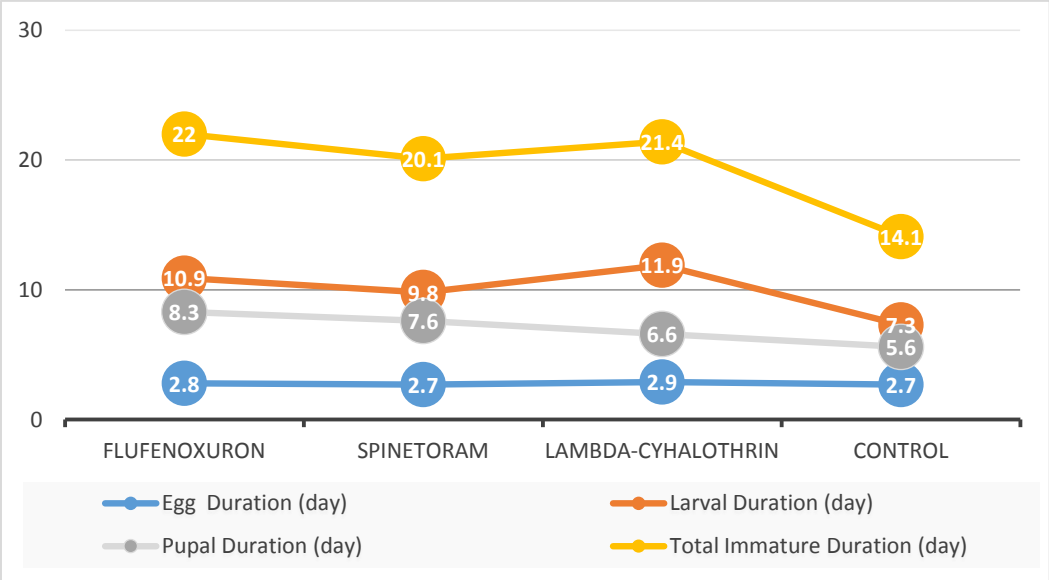


**Fig. 5. Indirect effects of tested compounds on immature durations of *Bracon breviconis* reared on treated host larvae of *P. gossypiella***

compounds Flufenoxuron, Spinetoram and Lambda-cyhalothrin treated larvae that recorded 10.9, 9.8 and 11.9 days/ larvae; and 8.3, 7.6 and 6.6 days/ cocoon for the previously mentioned compounds, respectively, in comparison to 7.3 days/ larvae and 5.6 days/ cocoon in control check. Thus the total periods required to *B. brevicornis* complete the different stages (from eggs to cocoons) were elongated to 22.0, 20.1, and 21.4 days for Flufenoxuron, Spinetoram, and Lambda-cyhalothrin treatments, respectively, compared with 14.1days in untreated check.

### 3.3.3 Latent effect on emerged adults of *B. brevicornis*

**Ovipositional Periods:** Data illustrated in Fig. 6 Indicated the variation in the life span between *B. brevicornis* female wasps as a result of the different treatments. For Flufenoxuron from immature parasitoid fed on host treatment and Spinetoram treatments, the pre-oviposition periods were elongated to record 2.9, 2.1 days, respectively, contrary to Lambda-cyhalothrin treatment that reduced this period to 1.4 days compared with 1.9 days in the control check. Besides, a severe reduction in the Oviposition periods (approximately to half time) was detected in Lambda-cyhalothrin treatment (6.0 days), followed by 8.3 and 9.6 days for female wasps in Spinetoram and Flufenoxuron treatments, respectively, compared with 12.3 days for untreated check. Furthermore, both Spinetoram and Lambda-cyhalothrin treatments affected the post oviposition by reduction to 2.1 and 1.4 days respectively, opposite to Flufenoxuron treatment that elongated the post oviposition period to 3.6 days compared to 2.5days for control check.

**Adult Longevity:** The effect of treated host larvae of *P. gossypiella* on the longevity of *B. brevicornis* adult female wasps appeared in Lambda-cyhalothrin treatment as it decreased approximately to half time (8.7 days /females) in comparison to 16.3 days/females in control check (Fig. 6). The reduction was extended, with a low degree, to include Spinetoram treatment as it recorded (13.1 days /female), with approximately no effect for Flufenoxuron treatment (16.1 days /female). Also, the longevity of emerged males of parasitoid *B. brevicornis* was reduced significantly in Lambda-cyhalothrin treatment (7.3 days /male) and non-significantly in Spinetoram treatment (11 days /male) opposite to Flufenoxuron treatment that caused a noticeable elongation in males longevity (14.1 days /male) in comparison to 11.3 days /male in control check.

**Reproductive Potential:** The latent effect of treating host larvae of *P. gossypiella* with tested insecticides was extended to affect eggs deposited by *B. brevicorns* females. Obtained results indicated highly adverse influences on the daily numbers of deposited eggs/ females for all treatments with more efficiency of Lambda-cyhalothrin treatment as it recorded (12.38 /♀/ day) followed by Spinetoram (13.13 /♀/ day) then Flufenoxuron (13.75 /♀/ day) in comparison to (16.02 /♀/ day) in control check. Subsequently, the total numbers of deposited eggs were significantly decreased to 74.3, 109.0, and 132.0 eggs/ female, for Lambda-cyhalothrin, Spinetoram, and Flufenoxuron treatments respectively, compared to 197.0 eggs/ female for untreated check (Fig. 7).

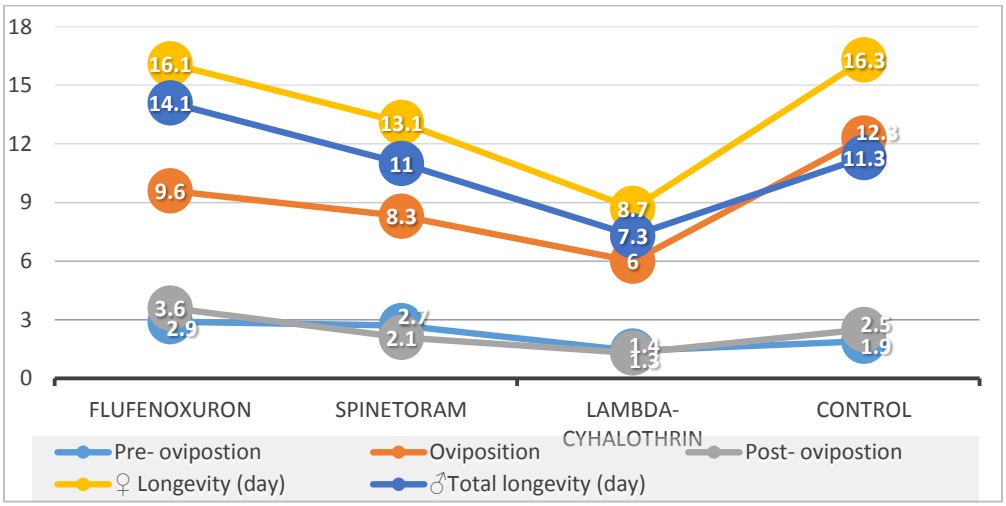


**Fig. 6. Latent effect of tested compounds on resulting adults of *Bracon brevicorns* reared on *P. gossypiella* treated larvae**

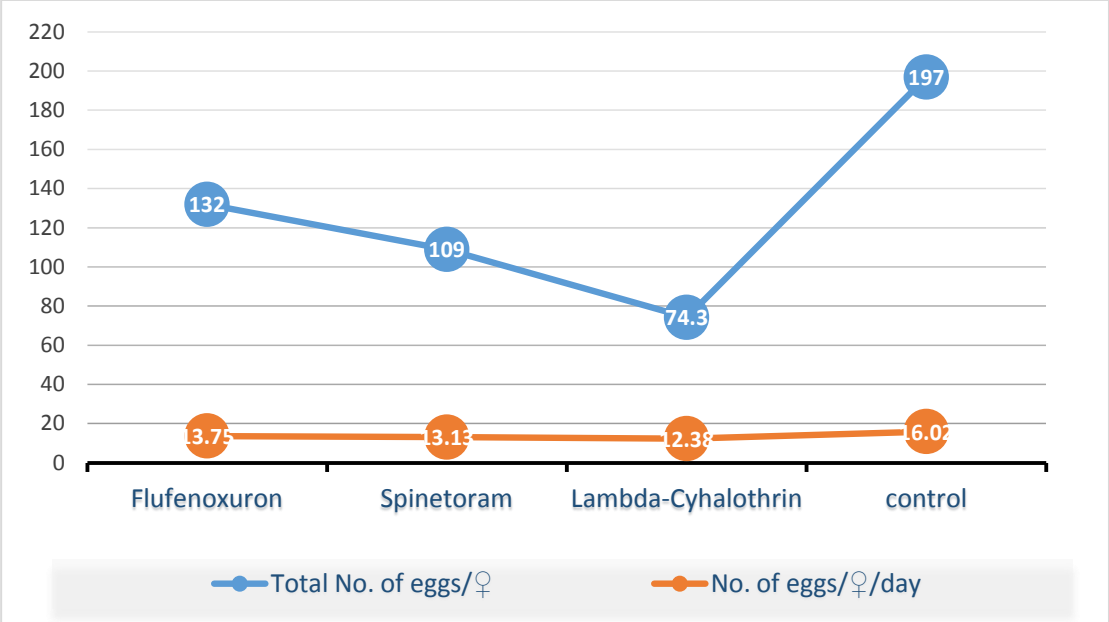


**Fig. 7. Effect of tested compounds on eggs production of *Bracon brevicorns* resulted in females**

**Hatchability and Sterility:** Female wasps of *B. brevicorns* are continuously provided with nutrients, during all their longevity, through the bloodstream of the paralyzed host. An indirect effect of feeding *B. brevicorns* females on *P. gossypiella* larvae treated with tested compounds represented by the massive reduction in the hatchability percents of deposited eggs. Flufenoxuron, Spinetoram and Lambda-cyhalothrin treatments recorded percent's of hatched eggs estimated by 69, 71 and 56 % respectively, compared to 98 % for untreated check that reflects the sterility percentage estimated by 31, 29 and 44 % for previously mentioned compounds respectively, compared to 2.0% for untreated check (Fig. 8).

## 4. DISCUSSION

The results declared that all treatments of Flufenoxuron, Spinetoram, and Lambda-cyhalothrin high toxic **o**n neonate larvae *P. gossypiella.* The $LC_{50}$ values Lambda-cyhalothrin is considered the highest potency and more toxic (0.358) followed by spinetoram (2.64) and Flufenoxuron (4.312), respectively. The data revealed that the Flufenoxuron

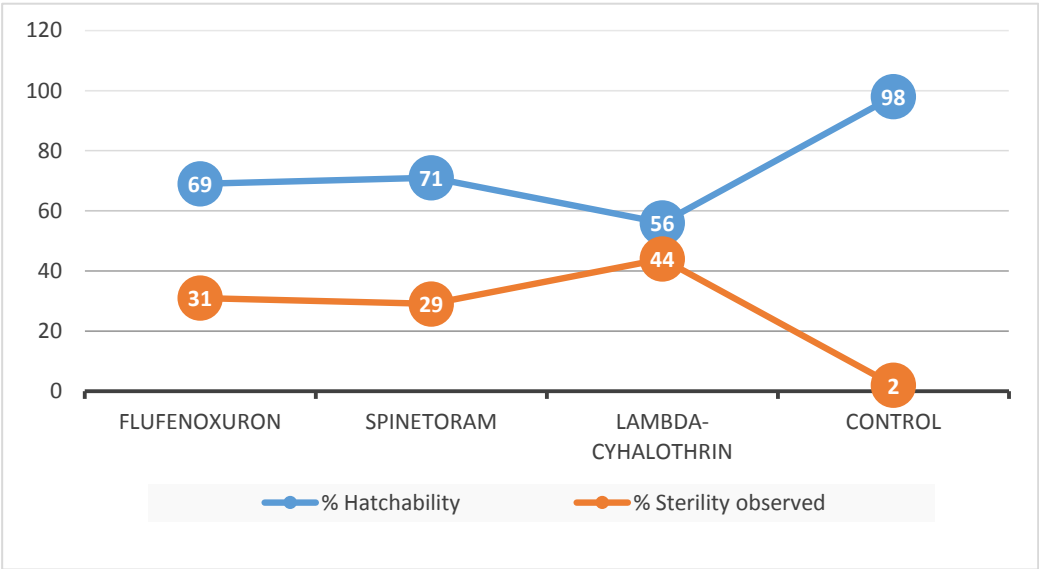


**Fig. 8. Effect of tested compounds on egg hatchability and sterility of *Bracon brevicorns* resulting adults**

compound has the lowest hazard on parasites than the two other insecticides. The results are getting along with that of Wirtz et al., [12] they recorded the high efficiency of pyrethroid against Lepidoptera pests followed by Spinetoram and IGRs, [25,26,27,28]. Also, Kandil, et al. [29] reported the toxicological effects of lufenuron, chlorfluazuron and chromafenozide against *Pectinophora gossypiella*, Kandil and Moustafa [6] recorded that the $LC_{50}$ was 0.7 with etofenprox and 0.87 ppm with chlorpyrifos when P. gossypiella was treated, while $LC_{50}$ was 0.09 and 0.73 ppm when *E. insulana* was treated with etofenprox and chlorpyrifos, respectively.

Our results also indicated that for all treatments; Flufenoxuron, Spinetoram, and Lambda-Cyhalothrin; both larval and pupal duration of *P. gossypiella were increased* to 23.5, 19.0, and 21.4 days/larvae and to 12.0, 13.4, and 13.0 days/pupa respectively, compared with 15.3 and 7.9 days in control for larvae and pupa, respectively. Subsequently, the total immature durations were highly elongated to reach 35.5, 32.4, and 34.7 days, for the previously mentioned compounds, respectively, compared with 23.2 days in the control check.

Our results are in agreement with that of El-Barkey et al., [30] they showed prolongation in larval and pupal developments of *P. gossypiella* resulting from treated eggs by Radiant and Hexaflumuron. Also, Reda et al., [31] on *Spodoptera littoralis* and Shaurub et al., [32] on *Agrotis ipsilon*, recorded a significant increase in the mean larval and pupal duration as a result of larval treatment with $LC_{50}$ of flufenoxuron (Cascade). Moreover, Moustafa and Salem [33] detected a prolongation in larval and pupal developments and so the total immature duration resulted from treated newly hatched larvae of *Pectinophora gossypiella* (Saund.) by cypermethrin and Flufenoxuron. Kandil and Moustafa [6] showed increase in the duration of larval and pupal stages of *P. gossypiella* and *E. insulana* when treated with etofenprox and chlorpyrifos compounds, with a corresponding increase in the mean larval mortality percentages that recorded 65.0 and 63.0% in treated *P. gossypiella*, while it was 71.0 and 66.0% in treated *E. insulana* for the two for mentioned compounds, respectively.

Results also declared that treatments affected on the time required for *B. brevicornis* to complete its total immature durations from eggs to cocoons stages as they elongated to 22.0, 20.1, and 21.4 days for Flufenoxuron, Spinetoram, and Lambda-cyhalothrin, respectively, compared with 14.1days in untreated. Moreover, a high reduction in the number of laid eggs and percent of hatchability was recorded.

Results are getting along with those of many authors who studied the effect of several insecticides on parasitoids; Anne et al, [34] reported that the pesticides' effect on the parasitoid *B. hebetor* causes an increase in both mortality and duration of immature stages. Also, Armenta et al., [35] stated high toxicity for the organo-phosphorus compound to insect natural enemies predators and parasites on maize. Subsequent studies of Khan et al., [36,37] reported that the pesticides' effects on the parasitoid *B. hebetor* cause an increase in the mortality and duration of immature stages. Also, Sarfaz et al., [38] added that Spinetoram has larger margins of safety for parasitoids and fits well in integrated pest management. In addition, Tabozada et al., [39] recorded indirect toxicity to the larval parasitoid *Bracon brevicornis* of Flufenoxuron compound. Similarly, Hooshang et al., [40] declared the effects of profenofos, spinetoram, and third carbon some biological parameters of *Habrobracon hebetor* with noticeable effect on Sex ratio. Faal [41] reported high potency to chlorpyrifos against H. hebetor. More similar findings were reported by Tabozada et al., [39] who indicated indirect toxicity effects for both Flufenoxuron and Lufenuron on the larval parasitoid *B. brevicornis* when applied on *S. littoralis* treated host larvae. In addition to, a clear reduction in Parasitism rate, adult emergence, and adult longevity. In addition, Ebeid, et al., [42] approved a toxic effect for the IGR (Runner) which was dangerous on all life stages of *B. hebetor*, influencing the activity and bioassay of the larvae as well as the number of laid eggs by the parasitoid. Our results also, are getting along with that obtained by Kandil and Moustafa [6] who indicated an elongation in the total immature stage duration and so the life cycle of *Bracon brevicornis* in comparison to control as indirect effects for feeding *B. brevicornis* parasitized on etofenprox and chlorpyrifos *P. gossypiella* treated larvae.

## 5. CONCLUSION

Generally, it can be concluded that the parasitoid *Bracon brevicornis* was highly affected when reared on Lambda-cyhalothrin, Spinetoram, and Flufenoxuron tested compounds *P. gossypiella* larvae as a treated host. Parasitism on treated hosts leads to elongation in the durations of parasitoid stages. The resulted female wasps reared on treated hosts laid fewer numbers of eggs compared to untreated ones. The reduction in total eggs numbers laid and progeny may be due to the host polluted blood that the wasps feed on during their all longevity which may cause an indirect effect on the fecundity as well as egg hatchability percentages.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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