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Effect of Host Plants on Predator Prey Relationship between Predatory Bug, *Orius laevigatus* (Fiber) [Hemiptera: Anthocoridae] and Tobacco Whitefly, *Bemisia tabaci* (Gennadius) [Homoptera: Aleyrodidae]

تأثير العوائل النباتية على علاقة الافتراس ما بين البق المفترس (*Orius laevigatus*) وذبابة التبغ البيضاء (*Bemisia tabaci*)

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Abstract

This study was conducted to investigate the effect of host plants on the predatory bug, *O. laevigatus*. Tobacco whitefly, *B. tabaci* was offered on tomato and eggplant leaf discs as food source for the predator in the laboratory at temperature of 25±1ºC, 75±5% R.H, and 16 L: 8 D photoperiod regime. Results showed that adults of *O. laevigatus* were able to feed on both eggs and larval instars of *B. tabaci* maintained either on tomato or eggplant. *O. laevigatus* preferred significantly ($P < 0.05$) feeding on *B. tabaci* eggs more than on larvae. Thus, the average daily consumption of adult *O. laevigatus* was 30.44 eggs and 3.2 larvae of *B. tabaci* infesting tomato but that on eggplant was 27.6 eggs and 2.45 larvae. In addition, fertility of *O. laevigatus* females was significantly greater when the predator fed on *B. tabaci* reared on tomato than that on eggplant. Thus, the average total nymphs produced by each *O. laevigatus* female fed on *B. tabaci* infestation were 64.5 when offered on tomato leaf discs, and 34.8 when offered on Eggplant leaf discs. Therefore, further laboratory and field studies were suggested to be carried out on practical use of *O. laevigatus* as a biocontrol agent against *B. tabaci* as a pest.

Key words: *Orius laevigatus*, *Bemisia tabaci*, Predator-Prey Relationship, Insect-Plant Relationships.

ملخص

تم تنفيذ الدراسة الحالية والتي شملت فحوصات مخبرية حول تأثير العوائل النباتية على حياة البق المفترس (*O. laevigatus*) عند استخدامه عاملا حيويا ضد ذبابة التبغ البيضاء (*B. tabaci*) وذلك على كل من نباتات البندورة والباذنجان، تحت ظروف مناخية ثابتة هي درجة حرارة 25±1°C، ورطوبة نسبية 75±5% وفترة إضاءة 16 L: 8 D. تشير النتائج المستخلصة من هذه الدراسة إلى أن الحشرات الكاملة للبق المفترس تمكنت من التغذية على بيوض الذبابة البيضاء ويرقاتها الموجودة على أوراق نباتات البندورة والباذنجان، كما أظهرت حشرات البق أفضلية احصائية في التغذية على بيوض الذبابة البيضاء أكثر من التغذية على يرقاتها. وأن معدل الافتراس اليومي للحشرات الناضجة للبق المفترس كان 30.44 من بيوض الذبابة البيضاء و٣.٢ من يرقاتها الموجودة على أوراق البندورة، في حين كان معدل الفتراس اليومي ٢٧.٦ من بيوض الذبابة البيضاء و ٢.٤٥ من يرقاتها الموجودة على أوراق الباذنجان. كما أظهرت النتائج أن معدل خصوبة البق المفترس كانت أعلى إحصائيا عندما قدمت الذبابة البيضاء للبق المفترس على أوراق البندورة منها على أوراق الباذنجان. وأن انثى البق المفترس قد أنجبت ما معدله ٦٤.٥ حورية عندما قدمت الذبابة البيضاء للبق المفترس على أوراق البندورة في حين كان معدل اللإنجاب ٣٤.٨ عندما قدمت الذبابة البيضاء للبق المفترس على أوراق الباذنجان. وبذلك تظهر النتائج المستخلصة من الدراسة ضرورة إجراء أبحاث مخبرية وحقلية حول إمكانية استخدام حشرة البق المفترس (*O .laevigatus*) عاملا حيويا لمكافحة حشرة الذبابة البيضاء (*B. tabaci*)

Introduction

Tobacco whitefly, *Bemisia tabaci* is a serious pest attacking several vegetable crops including tomato, cucumber, eggplant, tobacco and sweetpotato in temperate and tropical areas including Mediterranean region (Al-Antary & Sharaf, 1994; Greathhead, 1986; Holmer, *et al*., 1993; Holmer *et al*., 1994).

B. tabaci removes phloem sap and heavy infestation may result in spotting, yellowing and abscission of host leaves, reducing vigor, growth and yield of plant, and ultimately cause plant to die (Holmer, *et al*., 1991; Schuster, et al., 1991). It also transmits several viral diseases. Whitefly damages also plants through honeydew excretion serving as substrate for the growth of black sooty mould which lessens the market value of the products or renders yields unmarketable (Berlinger, 1986; Kring, *et al*., 1991; Polston, *et al*., 1993).

Many control measures have been used to restrict the spread and damage of *B. tabaci*. However, pesticides applied to control *B. tabaci* are often ineffective because immature stages live on the under side of the leaves limiting the amount of pesticides from reaching the target. In addition, intensive use of insecticides caused whitefly to develop resistance to many of the conventional insecticide, elimination of non target insects and pesticide residues caused environmental contamination (Cohhen & Berlinger, 1986; Hamon & Salguero, 1987). Therefore, alternative control methods were used recently to moderate the injury of whitefly. Some authors attempted to use natural enemies including specific parasitoids, predators, and entomopathogens to control this pest (Gerling, 1990; Breen, 1992; Holmer, *et al*., 1993; Breen *et al.,* 1994; Henneberry, *et al.,* 1994; Hamdan, 2006).

The importance of parasitoids such as *Encarcia spp.,* and *Eretmocerus spp.,* as biological control agents towards whitefly is well known (Gerling, 1996), but the possible role of predators as a natural regulation factor had received little attention. The predatory bug, *Macrolophus caliginosus* was recommended to be used as natural enemy against the greenhouse whitefly, *Trialeurodes vaporariurum* (Aleyrodidae) (Hamdan, 1997), meanwhile *Orius laevigatus* was used as predator against the greenhouse thrips, *Frankniella occidentalis* (Cocuzza, *et al*., 1997; Tommasini & Maini, 2001; Tommasini, *et al*., 2004). Recent study conducted by Abo-Awad, 2006 (Abu-Awad, 2006) showed that *O. laevigatus* is a promising biocontrol agent against *B. tabaci* infestation on tomato and eggplant plants.

The life span of an individual insect can be divided into two phases: the developmental period from egg hatching until adult eclosion referred to as nymphal stages, and then the period spent as an adult that usually referred to as adult longevity (Jervis & Copland, 1996).

The objective of this study is to investigate the indirect effect of tomato and eggplant occupied by *B. tabaci* on adult longevity, rate of consumption, and fertility of *O. laevigatus* when used as predator against *B. tabaci* under laboratory conditions of 25±1ºC, 75±5% R.H and 16 L:8 D photoperiod regime..

Materials and Methods

1. Host plants

Transplants of tomato (*Lycopersicon esculentum* L. cultivar: 16/84) and eggplant (*Solanum melongena* L. cultivar: Classic) were used for rearing *B. tabaci*. They were kept inside wooden and Perspex cages for obtaining leaf-discs which were used in bioassays.

2. Insect cultures

The predator bug, *O. laevigatus* was obtained from Bio-Bee Company belonging to Bio-Bee Biological Systems at Kibbutz Sde Eliyahu, Beit Shean Valley, Israel. They were provided in a package with two bottles; each contains 250 bugs. About 80% of the bugs were newly emerged adults and the rest were at 5^{th} nymphal instars mixed with Vermiculite carrier for ventilation. Upon receive of the package, each couple of newly emerged adult male and female, were transferred to a Petri dish for the experimental purposes.

To establish a stock culture of *B. tabaci* to be used for conducting this study, plant leaves infested with *B. tabaci* were collected from infested tomato plants planted in the nearby greenhouse, and placed on tomato, and eggplant transplants kept in the wooden cages and placed in a greenhouse at Faculty of Agriculture, Hebron University, Hebron, Palestine. Resulted insect cultures were used for bioassays.

3. Rearing cages

Woody cages: Four cages (1m length x1m width x1m height) were constructed with woody arms and covered with 50 mesh screen from all sides. Two cages were used to keep healthy transplants of tomato and eggplants, one cage was used to keep the culture of *B. tabaci* on tomato plants and one was used to keep culture of *B. tabaci* on eggplant plants.

Perspex cages: These cages were made from transparent Perspex material (50cm width x 70cm depth x 50cm height). To allow ventilation, a door of 50 mesh cloth (30cm width x 40cm high) was provided on the front of the cage. Ten cm diameter hole covered with 50 meshes net was provided in the rear side. The Perspex cages were placed on a metallic tray on laboratory bench with approximately 90cm high under room condition.

Those cages were used to keep the freshly infested tomato and eggplant transplants to be used as daily resource for the infested leaf discs provided to the bioassays.

Petri-dish cages**:** Each plate (5cm diameter x 1.5cm height) had hole of 2cm diameter in the middle of the lid, which was covered by 50 mesh cloth to provide ventilation. These cages were used for rearing of the predators on infested leaf discs in incubator under the experimental conditions.

4. Agar medium

Agar layer of 2 mm thick was used in Petri-dish cages as a source of nutrients as well as a source of moisture for the leaf-discs.

Fertilized Agar medium was prepared by adding Agar at rate of 15g/liter to plant growth fertilizer (20N:20P:20K) diluted in a distil water at a rate of 2gm/liter. The mixture was heated with a magnetic stirrer for 25 min on hot-plate for homogenizing and dissolving of Agar, then, autoclaved for 40 minutes at temperature of 120˚C under (1.4 bar) atmospheric pressure. After cooling to 45-50˚C, a fungicide solution prepared by dissolving 0.3g of Benlate® (50% Benomyl) in 7ml of ethanol 95% then added to 3ml of distilled water, was added to the Agar medium at rate of 1ml/liter of fertilized Agar.

The Benomyl was used to prevent the growth of mould on the agar layer. In addition, during the studies on the incubation period of *O. laevigatus* eggs, when growth of moulds occurred on the leaf-discs, a solution of 0.5ml/liter of Merpan® (50% Captan) was misted on the surface of the leaf-disc to keep it fresh and free of mould infestation for the incubation period of the *O. laevigatus* eggs.

5. Bioassays and evaluation of the predator’s efficiency

Bioassays were carried out during fall 2005 in laboratories of Hebron University, Hebron, Palestine. All tests were done in an incubator under standard conditions of 25±1ºC, 75±5% R.H and 16 L: 8 D photoperiod regime.

To obtain tomato and eggplant transplants that are infested with *B. tabaci* eggs and larvae to be used as prey for the predatory bugs, healthy Transplants of tomato and eggplants were inserted in between the heavy infested plants kept in the woody cages. Then those freshly infested transplants were transferred to the Perspex cages and kept under room conditions, to be used as a source of leaf discs that infested with eggs and larvae of *B. tabaci* used in bioassays.

Twenty replicates were reared on each host plant (tomato and eggplant). Each replication consisted of couple of newly emerged adults of *O. laevigatus* reared in 5cm diameter Petri dish cage and offered tomato or eggplant leaf disc heavily infested with *B. tabaci* eggs and larvae. The predators were provided with infested leaf-discs placed underside upwards on 2mm-thick Agar medium. A filter paper was used as a layer between the leaf-disc and the Agar medium enabling the free movement of the insects and decreasing the possibility of their sticking to the Agar.

Each couple was transferred to freshly prepared cages every day and the previous leaf discs from each cage were kept in the incubator under the standardized conditions during incubation period of eggs and then observed for egg hatching.

A solution of 0.5ml/liter of Merpan® (50% Captan) was sprayed on the leaf discs to prevent the growth of mould on the leaf surface.

The following parameters of *O. laevigatus* were observed for each replication:

1. Adult longevity was monitored at 24 h intervals.
2. Oviposition period and post-oviposition period for each female monitored by daily observation of the presence of eggs of *O. laevigatus* in leaf discs where females reared.
3. Daily consumption for each couple recorded by daily counting the number of empty shells of whiteflies eggs and larvae consumed by the predators.
4. Fertility of *O. laevigatus* females reared on both tomato and eggplant leaf discs recorded by daily observation and counting the number of nymphs hatched from cages where the *O. laevigatus* females were reared.
5. In this study and, due to the difficulty of counting the eggs laid per female, the fecundity was considered as the number of newly hatched nymphs from eggs oviposited by every female and referred to as fertility
6. Statistical analysis was done by MINITAB package using t-test analysis. Standard error of the means was calculated and added to the data.

Results

Results show that *O. laevigatus* was able to feed and live on *B. tabaci* kept either on tomato or eggplant. *O. laevigatus* females and males fed on whitefly from tomato lived for 20.1 and 16.6 days respectively and, longevity of adult reared on prey from eggplant leaves was 16.5 days for females and 13.9 days for males (Table 1). Results in Table 1 also show that, the oviposition periods of *O. laevigatus* females reared on tomato and eggplant were 18.35 and 15.35 days, respectively and, the post oviposition period of *O. laevigatus* females were 2.25 days on tomato and 1.65 days on eggplant. However, no significant effects of host plant were detected on adult longevity, oviposition periods or post oviposition periods.

Table (1): Adult longevity, oviposition and preoviposition of O. laevigatus fed on B. tabaci infestation offered on either tomato or eggplant. Mean (days) ± S.E.

Host plant(n)	**Adult longevity of males**	**Adult longevity of females**	***P value***	**Oviposition period/ female**	**Postoviposition period/ female**
Tomato (20)	16.60±2.80	20.10±3.19	0.41NS	18.35±2.49	2.25±0.72
Eggplant (20)	13.95±1.76	16.50±2.32	0.39NS	15.35±1.94	1.65± 0.54
P value	0.43 NS	0.367NS		0.35NS	0.51NS

NS: Not significant at P value ≤ 0.05 (using t-test analysis).
n = number of replications.

Results in Table 2 show that adults *O. laevigatus* consumed an average total of 770 of *B. tabaci* stages (706 eggs, and 64 larvae) that were reared on tomato leaf discs during it's life cycle. Meanwhile, the average total consumption of adult *O. laevigatus* reared on eggplant leaf discs was 485 of *B. tabaci* stages (453 eggs and 32 larvae).

Table (2): Total consumption of O. laevigatus during its adult longevity when fed on eggs and larvae of B. tabaci on either tomato or eggplant**.**

Host plant(n)	**Eggs consumption/ adult**	**Larvae consumption/ adult**	***P value***	**Eggs + Larvae consumption / adult**
Tomato(20)	706 ± 131	64.4±10.7	0.001*	770 ± 141
Eggplant (20)	453 ± 72.6	32.33±3.78	0.001*	485.3±76.3
P value	0.099NS	0.008*		0.084NS

NS: Not significant at P value ≤ 0.05 (using t-test analysis).
n = number of replications.
*: with significant differences at *P value* ≤ 0.05 (using t-test analysis)**.**

Statistical analysis show that, *O. laevigatus* was with a significant preference for feeding on *B. tabaci* eggs more than on larvae when offered on either tomato or eggplant leaf discs. In addition, total consumption of *O. laevigatus* from *B. tabaci* larvae offered on tomato was significantly higher than that offered on eggplant leaf discs. However, no significant effect was detected for the host plant factor on the total consumption of *O. laevigatus* from *B. tabaci* eggs offered either on tomato or eggplant leaf discs.

Results in Table 3 show that, the daily consumption rate of adult *O. laevigatus* reared on tomato leaf discs was 33.65 of *B. tabaci* stages (30.44 eggs, and 3.20 larvae), whereas, the daily consumption rate of *O. laevigatus* reared on eggplant leaf discs was 30.06 of *B. tabaci* stages (27.61 eggs and 2.45 larvae). Statistical analysis shows that rate of daily consumption of *O. laevigatus* from larvae of *B. tabaci* was significantly higher on tomato than on eggplant.

Table 3: Daily consumption rate of adult O. laevigatus fed on eggs and larvae of B. tabaci on either tomato or eggplant. Mean ± S.E.

Host plant(n)	**Egg consumption/ adult**	**Larvae consumption/ adult**	***P value***	**Eggs + Larvae consumption/ adult**
Tomato (20)	30.44±1.84	3.20±0.15	0.001*	33.65±1.87
Eggplant (20)	27.61± 0.65	2.45± 0.15	0.001*	30.06± 0.56
P value	0.154NS	0.001*		0.074NS

NS: Not significant at P value ≤ 0.05 (using t-test analysis).
n = number of replications.
*: with significant differences at *P value* ≤ 0.05 (using t-test analysis).

Results obtained in Table 4 show that, the total nymphs hatched per female from tomato leaf-discs (64.55 nymphs/female) was significantly higher than that hatched from eggplant leaf discs (34.85 nymphs/female). In addition, the average number of nymphs hatched per female per day of its oviposition period was also significantly higher from tomato leaf-discs (3.67 nymphs/female/day) than that from eggplant leaf discs (2.37 nymphs/female/day).

Table (4): Number of nymphs hatched from eggs of O. laevigatus per female fed on B. tabaci infestation on either tomato or eggplant. Mean ± S.E.

Host plant(n)	**Total nymph/ female**	**Average nymph/ female/day**
Tomato (20)	64.55±8.83	3.67±0.21
Eggplant (20)	34.85±4.05	2.37±0.15
P value	0.005*	0.001*

n = number of replications.

*: with significant differences at *P value* ≤ 0.05 (using t-test analysis).

Discussion

Some authors reported that adult longevity of *O. laevigatus* are strongly influenced by prey species and host plants (Zaki, 1989; Tommasinin, *et al*., 2004). Results of the present study show that, the adult longevity of *O. laevigatus* reared on *B. tabaci* offered on tomato found to be longer than that reared on eggplant but the difference detected was not statistically significant. The present study show that adult longevity of female *O. laevigatus* fed on *B. tabaci* offered on tomato (20 days) was approximately similar to that recorded by Tommasini *et al*., (2004), which reported that adult longevity of female *O. laevigatus* was 18 days when reared on *Frankniella occidentalis* adults, meanwhile, Tommasini, *et al*., (2004), reported that adult longevity of female *O. laevigatus* was 38.6 days when fed on eggs of *Ephestis kuehniella*, under the same conditions of the present study. The difference in adult longevity of *O. laevigatus* between results was reported by several authors (Cohhen & Berlinger, 1986; Zaki, 1989; Tommasini, *et al*., 2004) might be due to the differences in prey species and host plant.

When *O. laevigatus* reared on eggs of *E. kuehniella* offered on pepper as a host plant, at 23°C, 60 ± 5% R.H and 16 L: 8 D regimes (Cocuzza, *et al*., 1996), it was found that, the adult longevity for both sexes was longer than that recorded in the present study on either tomato or eggplant. Moreover, Zaki (1989), reported that the adult longevity of females of *O. laevigatus* was longer than that of males which was in agreement with that found in the present study.

In addition, the oviposition periods recorded in this study on tomato (18.3 days) and on eggplant (15.3 days) were shorter than that recorded by Cocuzza, *et al*., (1996), which was conducted on Spanish pepper. It was found that oviposition period of *O. laevigatus* was 49.2 days when fed on *E. kuehniella* eggs, 54.3 days on *E. kuehniella* eggs plus pollen and 51.9 days on pollen only (Cocuzza et al., 1996). Thus the difference in oviposition period between the present study and Cocuzza, *et al*., (1996), might be due to the differences in botanical characteristics of host plants and the prey species.

Several studies reported that the fecundity of *O. laevigatus* was found to be highly variable according to prey species (Mound, 1963; Cocuzza, *et al*., 1996; Tommasini, *et al*., 2004). The present study show that, the average total number of *O. laevigatus* nymphs hatched/female was 64.55 when reared on tomato and 34.85 nymphs/female reared on eggplant. The fertility of *O. laevigatus* fed on *B. tabaci* infestation on either tomato or eggplant recorded in the present study was lower than that recorded by Tommasini *et al*., (2004) when they reared *O. laevigatus* on *E. kuehniella* eggs, but higher than that of *O. laevigatus* reared on *F. occidentalis* adults as prey.

In addition, results of the present study show that the average fertility of *O. laevigatus* fed on *B. tabaci* infesting either tomato (64.5 nymphs/female) or eggplant (34.8 nymphs/female) was lower than that recorded by several researchers whom reared *O. laevigatus* on different prey species (Zaki, 1989; Alauzet, *et al*., 1994; Cocuzza *et al*., 1997; Tommasini *et al*., 2004). The average fecundity of *O. laevigatus* reared under constant conditions of 23°C and 60 ± 5% R.H was 183.7 eggs/female when fed on *E. kuehniella* eggs; 187.9 when fed on *E.*

kuehniella eggs plus pollen; and 79.2 on pollen only and third study (Tommasini, *et al*., 2004).

Results of the present study show that the predatory bug, *O. laevigatus* significantly preferred consumption of eggs over larvae of *B. tabaci* reared on either tomato or eggplant under the condition of the experiment. This preference was similar to that reported by Hamdan (1997), who found that the predatory bug, *Macrolophus caliginosus* showed a significant preference to feeding on eggs of greenhouse whitefly, *Trialeurodes vaporariorum* than larvae or pupae.

Results of the present study showed that host plant species had significant effects on some life cycle aspects of the predatory bug, *O. laevigatus* when fed on tobacco whitefly, *B. tabaci* infesting either tomato or eggplant. These results were in agreement with Hamdan (2006), who studied the effect of host plant species on life cycle aspects of predatory bug, *Macrolophus caliginosus* fed on greenhouse whiteflies, *T. vaporariorum*. It was reported that host plant species had significant effects on survival, adult longevity and fertility of the predatory bug, *M. caliginosus* when fed on greenhouse whiteflies, *T. vaporariorum* infesting same host plants. *O. laevigatus* fed on both eggs and larvae of *B. tabaci* when reared on tomato or eggplant (Hamdan (2006).

Therefore, it's recommended to conduct further laboratory and field studies on practical uses of *O. laevigatus* as biological control agent against *B. tabaci* infestation on tomato and eggplant crops.

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