Dirasat, Agricultural Sciences, Volume **35**, No. **1 and 2**, 2008

Biological Aspects of the Predatory Bug *Orius laevigatus* (Fiber) [Hemiptera: Anthocoridae] When Fed on the Tobacco Whitefly *Bemisia tabaci* (Gennadius) [Homoptera: Aleyrodidae] Spread on Tomato and Eggplant

Abdul-Jalil S. Hamdan and Iyad T. Abu-Awad *

ABSTRACT

The present study constitutes laboratory investigation of the life history parameters of the predatory bug Orius laevigatus (Fiber) when predated on the tobacco whitefly Bemisia tabaci (Gennadius). The later was offered on tomato and eggplant leaf discs under laboratory constant conditions of 25±1˚C, 75±5% R.H and 16 L: 8 D photoperiod regime. Both nymphs and adults of O. laevigatus were able to feed on eggs and larvae of B. tabaci when offered on tomato or eggplant leaf discs. The preference for feeding on B. tabaci eggs was higher than that on larvae. During all nymphal stages, O. laevigatus consumed an average of 364.7 and 283.5 of B. tabaci eggs and larva when reared on tomato and eggplant leaf discs, respectively. In addition, during adulthood, adult females of O. laevigatus consumed an average of 883 and 455 of B. tabaci eggs and larva when reared on tomato and on eggplant, respectively. Thus, adult longevity and fertility of O. laevigatus were greater when fed on B. tabaci infestation offered on tomato rather than on eggplant. The survival of O. laevigatus was found to fit to Type II when fed on B. tabaci infestation offered on tomato, but to Type III on eggplant. The rate of predation and fertility of O. laevigatus was affected by the host plant. Further investigations have to be done on the practical use of O. laevigatus as a bio-control agent against B. tabaci infestation on tomato and eggplant.

Keywords: Orius Laevigatus, Bemisia Tabaci, Predator-Prey, Insect-Plant.

1. INTRODUCTION

The tobacco whitefly, *Bemisia tabaci* (Gennadius) [Homoptera: Aleyrodidae] has been known as a serious insect pest on tomato and other vegetable crops including cucumber, eggplant and tobacco in temperate and tropical areas (Greathead, 1986; Mustafa and Al-Momany, 1990; Hoelmer *et al*., 1993; and 1994).

Heavy infestation with *B. tabaci* causes removal of the sap from phloem resulting in leaf spotting, yellowing and abscission, reducing plant vigor, growth and yield and finally plant death (Hoelmer *et al*., 1991; Schuster *et al*., 1991). It also transmits the virus diseases, and causes damage to the plant by producing honeydew that serves as a substrate for the growth of black sooty mold (Berlinger, 1986; Kring *et al*., 1991; Polston *et al*., 1993).

Different control measures have been tested to reduce the spread of *B. tabaci*. The chemical control of *B. tabaci* is very difficult due to the occurrence of the immature stages on the lower side of the leaf. In addition, the intensive use of insecticides results in the development of resistant strains (Cohhen and Berlinger, 1986; Hamon and Salguero, 1987). So, alternative control measures are needed to control whiteflies. Some authors (Gerling, 1986; Gerling, 1990; Breene, 1992; Hoelmer *et al*., 1993; Breene *et al*., 1994; Henneberry *et al*., 1994; Hamdan, 1997), suggested using of biological enemies including specific parasitoids, predators and entomopathogens, and therefore, a debate has been raised on the effective biological agents.

The importance of parasitoids such as *Encarcia* spp., and *Eretmocerus* spp., is well understood (Gerling, 1996), but the role of the predators has been given little attention. Hamdan (1997) suggested the possibility of using *Macrolophus caliginosus* as a predatory bug against the greenhouse whitefly *Trialurodes vaporariurum*. Other researchers (Cocuzza *et al.,* 1997; Tommasini and Maini, 2001; Tommasini *et al.,* 2004) recommended the use of *Orius laevigatus* (Fiber) as a predatory bug against the greenhouse thrips *Frankniella occedentalis*.

* Department of Plant Production and Protection, Faculty of Agriculture, Hebron University, Hebron, Palestine. Received on 22/10/2007 and Accepted for Publication on 26/2/2008.

Tomato and eggplants are the most important vegetable crops in Palestinian territories (PCBS, 2006), and both crops were recorded to be heavily infested with *B. tabaci* (Abu Awad, 2006). However, to my knowledge, no published literature was found about using natural enemies to control the *B. tabaci* infestation in Palestinian territories, meanwhile, the predatory bug *O. laevigatus* is currently used as a predatory bug against the greenhouse thrips *Frankniella occedentalis* in the nearby vegetable fields in Israel. In addition, Hamdan (1997) found that the predatory bug *M. caliginosus* was able to feed on several prey species including aphids, thrips and whiteflies.

The aims of this study are to test the possibility of using the predatory bug, *O. laevigatus* as a biocontrol agent against *B. tabaci* infestation on tomato and eggplants, to investigate the rate of consumption of the predatory bug *O. laevigatus* fed on the *B. tabaci* infestation on leaf discs of both tomato and eggplant and to check the effect of host plant on the lifecycle parameters of the predatory bug.

2. MATERIALS AND METHODS

The predatory bug, *O.laevigatus* was obtained from the local Bio-Bee Company. 80% of the bugs were adults and the rest were at 5th instar nymphs. Adult males and females were kept in Petri dishes for the experimental purposes.

Adults as well as pupae and larvae of *B.tabaci* were collected from infested host plants in the greenhouse. Adults and leaves infested with pupae of *B. tabaci* were released on tomato (*Lycopersicon esculentum* L. cv 16/84), and eggplant (*Solanum melongena* L. cv Classic) and kept in woody cages at the greenhouse of the Faculty of Agriculture at the Hebron University. Healthy plants of tomato and eggplant were inserted in between the heavily infested plants to obtain tomato and eggplant transplants that were infested with *B. tabaci* eggs and larvae to be used as a prey for the predatory bugs. The heavily infested transplants were kept in Perspex cages to be used as a source of leaf discs that were infested with eggs and larvae of *B. tabaci*.

Petri-dish cages (5cm diameter x 1.5cm height) were used for rearing of the predators on infested leaf discs in incubator under the experimental conditions. A hole of 2cm diameter was made in the middle of the lid, and covered by 50 mesh cloth to provide ventilation. 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. The agar medium was prepared at a rate of 15g/l and was mixed with a 20:20:20 (N: P: K) plant growth fertilizer diluted at a rate of 2g/l of distilled water. The mixture was heated on a hot-plate with a stirrer for 25 minutes for mixing and dissolving the agar, then autoclaved for 40 minutes at 120˚C under (1.4 bar) atmospheric pressure. After cooling to 45-50˚C, a fungicide solution 0.3g of Benomyl 90% WP were dissolved in 7ml of ethanol 95% and added to 3ml of distilled water) was added at a rate of 1ml/l of fertilized agar (Hamdan, 1997). Ethanol 95% was used to dissolve the fungicide before adding it to the agar.

In addition, during the incubation period studies on *O. laevigatus* eggs, when growth of molds occurred on the leaf-discs, a solution of 0.5ml/l of Mervan (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.

A complete lifecycle study of *O. laevigatus* was conducted in a growth cabinet under standardized conditions of 25±1˚C, 75+5 % R.H and 16 L: 8 D photoperiod regime. This study investigated the life history parameters of the both nymphs and adults of the predatory bug *O. laevigatus* when offered a heavy infestation of *B. tabaci* as food (200-300 whitefly eggs and larva/cage/day) on both tomato and eggplant leaf discs.

Fifty newly hatched nymphs which collected from Petri dish cages where the bugs were reared on tomato leaf disks were used. And another fifty newly hatched nymphs which collected from cages where the bugs were reared on eggplant cages were used. Each nymph was separately reared in a 5cm diameter Petri dish on heavy infestation of *B. tabaci* offered on tomato or eggplant leaf-discs according to their previous host plant. These nymphs were daily transferred to freshly prepared Petri dish cages by a fine paint brush while checking them down a binocular dissecting microscope (40X).

The following life cycle parameters of *O. laevigatus* nymphal instars were assessed by daily checking during nymphal development. These were duration of development for each nymphal instar, from egg oviposition-adult emergence, by observing the presence of moult cast, mortality and survival of each bug from egg oviposition to adult stage and daily consumption of each nymphal stage.

Upon molting to adult, each individual of *O.*

laevigatus was checked for its sex, and to ensure mating. Each group of adults that emerged daily, was caged for one day in a 10cm diameter Petri dish and offered heavy infestation of *B. tabaci* on tomato or eggplant leaf discs according to their previous host plant

Six adult males of *O. laevigatus* obtained from tomato leaf discs were killed accidentally during the transfer. Therefore, 15 females and 9 males that survived to adult stages were reared for the adult longevity on tomato treatment, but only 4 females and 6 males survived from eggplant leaf discs and reared for adulthood period on eggplant.

On the second day, males and females were separately transferred to a 5cm diameter Petri dish and supplied with heavy infestation of *B. tabaci* on leaf discs of their previous host plant.

Each adult of *O. laevigatus* was daily transferred to newly prepared Petri dish cages and the previous leaf discs for each female were also transferred to freshly prepared cages and incubated under the standardized conditions. Leaf discs were sprayed with 0.5ml/l of Mervan (50% captan) to prevent the growth of mold then leaf discs were checked daily for the possible emergence of nymphs.

The following aspects were daily observed on the adult *O. laevigatus* fed on whitefly eggs and larvae on both tomato and eggplant leaf discs. These were adult longevity for males and females; oviposition period and post-oviposition period for each female; fecundity of *O. laevigatus* females reared on both tomato and eggplant leaf discs, and daily consumption for each *O. laevigatus* during its adulthood. Fecundity was considered as the number of the newly hatched nymphs from eggs laid by every female, due to the difficulty to count the eggs laid/females.

Statistical Analysis

Statistical analysis was done using MINITAB package. Comparisons were done using T-test to find out if there was a significant effect of the host plants on the studied parameters of the predatory bug *O. laevigatus* when preyed on *B. tabaci* offered on either tomato or eggplant leaf discs. In addition, T-test analysis was used to find out if there was significant preference in the consumption of the prey stages.

Survivorship Curves

For statistical comparison between treatments to be biologically meaningful, the data are best presented in a way that shows the cohort survival curves, which showed the fraction of each cohort surviving at a particular moment in time (Jervis and Copland, 1996). They (1996) suggested three categories of survivorship curves. These were type I, in which the risk of death increases with age; type II, in which a constant risk of death; and type III, in which the risk of death decreases with age. Therefore, results of survivorship were presented in Fig. (1) to find out the type of survival curve of *O. laevigatus* when preyed on *B. tabaci* offered on either tomato or eggplant leaf discs.

3. RESULTS

Development of *O. laevigatus*

O. laevigatus was found to have three developmental stages. These were egg, five nymphal instars and adult. The female inserted its egg in the major veins of the leaf-discs and then hatched to shiny and colorless first nymphal instars. After a few hours, the nymph turned into a yellowish colour that turned to orange in the second and third nymphal instars. The fourth and fifth instars turned to dark brown and the shape of their body resembled the adult. The presence of moulting casts was used to distinguish the end of each nymphal instar. The color of the adult was brown-black with gray spots. The female and the male could be distinguished from each other by the tip of their abdomen, which was pointed in the female.

All nymphal instars and adults of *O. laevigatus* were observed feeding on eggs and larvae of *B. tabaci* offered on tomato or eggplant leaf discs. Data presented in Table 1 showed that when rearing *O. laevigatus* nymphs on *B. tabaci* infestation offered on either tomato or eggplant leaf discs the total development from laying of eggs to adult emerge was significantly shorter on tomato (16. 7 days) than on eggplant (17.3 days). While the average incubation period of *O. laevigatus* eggs inserted in either tomato or eggplant oviposition sites did not significantly differ. The total duration of development of *O. laevigatus* nymphs was significantly shorter on tomato (12.3 days) than on eggplant (13.2 days).

The influence of the host plant on the duration of development of *O. laevigatus* nymphs was significant at 4^{th} and 5^{th} nymphal instar, but non-significant at the 1^{st}, 2^{nd} and 3^{ed} instars at *P value<0.05%*.

Longevity of *O. laevigatus* adults

The adult longevites of *O. laevigatus* females and males reared on tomato leaf discs were 25.6 and 22.3 days, respectively, while on eggplant leaf discs were 15 and 14 days for females and for males, respectively (Table 2). Thus, adult longevities of *O. laevigatus* females and males reared on *B. tabaci* infestation offered on tomato leaf discs were higher than that reared on eggplant leaf discs. Statistical analysis showed significant differences in female longevity but not in male longevity at *P value <0.05%*.

Also, on both hosts, adult longevity of females of *O. laevigatus* was higher than that of males. Results further showed that the oviposition period of *O. laevigatus* females reared on tomato and eggplant leaf discs was 18.3 and 12.8 days and, the post oviposition period of *O. laevigatus* females was 7.2 and 2.3 days on tomato and on eggplant respectively. However, statistical analysis showed that the host plant did not showed any significant effect on the adult longevity of males and oviposition period or post oviposition period of the *O. laevigatus* females reared on tomato or eggplant leaf discs at *P value<0.05%*.

Fecundity of *O. laevigatus* Females

Data presented in Table (3) show that the total number of nymphs hatched per *O. laevigatus* female reared on tomato leaf discs was 71.5 with a daily average of 4.0 nymphs. The total number of nymphs hatched per *O. laevigatus* female reared on eggplant leaf discs was 30.3 with daily average of 2.7 nymphs. Statistical analysis using T-test showed that the host plant has a significant role on the fertility of *O. laevigatus* where it was significantly higher at *P value<0.05%* when reared on tomato than on eggplant.

Mortality and Survival of *O. laevigatus*

Results presented in Table (1) also showed that mortality fraction of *O. laevigatus* nymphs reared on eggplant leaf discs was higher at the 1st nymphal instar (40%), while, the lowest mortality fraction occurred at the 4th nymphal instar (4%). However, on tomato leaf discs, mortality distribution was found to be low (4%) at N1 and N2, and high (16%) at N3 and at N5. Thus, total mortality of *O. laevigatus* nymphs from 1st to 5th instar was 80% and 405 on eggplant and tomato leaf discs respectively. In addition, the percentage of females survived to adults compared was 50% and 40% for the tomato and the eggplant leaf-discs, respectively.

The results in Fig. (1) showed that the survival curves of *O. laevigatus* adults fed on *B. tabaci* stages fit Type II (Jervis and Copland, 1996), when *B. tabaci* was offered on tomato leaf discs, in which a constant risk of death was observed during all stages, but fit Type III (Jervis and Copland, 1996), when *B. tabaci* offered on eggplant, in which the risk of death in adult *O. laevigatus* was higher at the nymphal stages. In addition, about 30% of the adults of *O. laevigatus* reared on tomato were still alive when the last adult of *O. laevigatus* reared on eggplant died. The maximum life span of *O. laevigatus* was about 8 weeks when reared on tomato and up to 4 weeks on eggplant.

Consumption of *O. laevigatus*

Results in Tables (4) and (5) show that during their development, *O. laevigatus* nymphs consumed a total of 364.7 and 283.5 *B. tabaci* eggs and larvae that were offered on tomato and eggplant leaf discs respectively. And the daily average consumption was 26.7 and 19.3 *B. tabaci* eggs and larvae on tomato and eggplant leaf discs, respectively.

The statistical analysis of the results in Table (4) revealed that the total consumption at all nymphal stages of *O. laevigatus* reared on tomato leaf discs was significantly higher than that on eggplant leaf disks, with an exception occured at the first nymphal stage where host plant did not have a significantly affect on the total consumption from both *B. tabaci* eggs and larvae offered on either tomato or eggplant leaf discs. Analysis of the results in Table (5) also showed that the average daily consumption of all nymphal stages of *O. laevigatus* reared on tomato leaf discs was significantly higher than that reared on eggplant. All nymphal stages of *O. laevigatus* were found to have a significant preference for feeding on *B. tabaci* eggs over larvae offered on both tomato and eggplant leaf-discs.

4. DISCUSSION

Development *of O. laevigatus*

The duration of egg of *O. laevigatus* was approximately similar in both tomato and eggplant leaf discs, while the total duration of nymphal development was significantly shorter on tomato than on eggplant. However, the longest nymphal instar was recorded at the 5th instar on both tomato and eggplant. The duration of egg of *O. laevigatus* in tomato and eggplant oviposition sites was approximately similar to that reported by

Cocuzza *et al.* (1997) in pepper. In addition, the total developmental time of *O. laevigatus* fed on *B. tabaci* infestation was also approximately similar to that reported by several authors (Cocuzza *et al.*, 1997; Tommasini *et al*., 2004). Similar results about the developmental time were found by Riudavets (1995) who studied the developmental time of *O. laevigatus* when fed on nymphs of *F. occidentalis*.

Adult longevity *of O. laevigatus*

Several authors (Zaki, 1989; Tommasini *et al.,* 2004) have reported that adult longevity of *O. laevigatus* was found to be strongly influenced by the prey species and the host plant. The results of the study showed that adult longevity of *O. laevigatus* reared on *B. tabaci* offered on tomato was higher than that reared on eggplant. The adult longevity of *O. laevigatus* in this study was found to be higher when reared on tomato than that by Tommasini *et al.* (2004) who found that adult longevity of *O. laevigatus* was 18 and 18.9 days for the females and the males respectively, when fed on *F. occidentalis* adults, under the same conditions. And adult longevity of the female *O. laevigatus* fed on eggs of *E. kuehniella* under the same conditions was higher (38.6 days), than that found in this study, when *O. laevigatus* was fed on *B. tabaci* infestation.

Cocuzza *et al.* (1996) reported that adult longevity of *O. laevigatus* when 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, was 57 and 41.9 days for the females and males, respectively. These values were higher than those recorded in the present study on tomato and eggplant. Moreover, results of this study are in agreement with that of some authors (Zaki, 1989; Cocuzza *et al.*, 1996) who found that adult longevity of the females of *O. laevigatus* was higher than that of the males. The oviposition period on tomato and eggplant was shorter than that recorded by Cocuzza *et al* (1996) in their study conducted at 23ºC, 60±5% R.H and 16L: 8D photoperiod on Spanish pepper. These authors found that the oviposition period of *O. laevigatus* was 49.2, 54.3 and 51.9 days when fed on *E. kuehniella* eggs, *E. kuehniella* eggs + pollen and on pollen only respectively. The results of the present study showed that the oviposition period of *O. laevigatus* was15.4 and 12.8 days on tomato and eggplant, respectively.

Thus, the difference in adult longevity and in oviposition period of *O. laevigatus* reported by several authors (Zaki, 1989; Cocuzza *et al.,* 1996; Tommasini *et al*, 2004) and that of this study could be due to the differences in the prey species and the host plant.

Fecundity *of O. laevigatus*

The fecundity of *O. laevigatus* was found to be vary the prey species (Cocuzza *et al*. 1996; Tommasini *et al*. 2004). The average total number of *O. laevigatus* nymphs hatched/female was 71 and 30 when reared on tomato and on eggplant respectively. In comparison with other studies, the fecundity of *O. laevigatus* fed on *B. tabaci* infestation on either tomato or eggplant recorded in our study was lower than that recorded by Tommasini *et al*. (2004), when *O. laevigatus* reared on *E. kuehniella* eggs, but higher than that of *O. laevigatus* reared on *F. occidentalis* adults as a prey. In other hand, our results showed that the average fecundity of *O. laevigatus* fed on *B. tabaci* infestation on either tomato or eggplant was found to be lower than that reported by several researchers on different prey species (Zaki, 1989; Alauzet *et al*. 1994; Cocuzza *et al*. 1997). Cocuzza *et al*. (1997) found that the average fecundity of *O. laevigatus* reared under constant conditions of 23°C and 60 ± 5% R.H was 183.7, 187.9 and 79.2 eggs/female when fed on *E. kuehniella* eggs; *E. kuehniella* eggs + pollen and on pollen only respectively. Zaki (1989) reported that the average fecundity *O. laevigatus* was 160 eggs/female, while that reported by Alauzet *et al*. (1994) was 158 eggs/female.

Mortality and Survival Curve *of O. laevigatus*

The mortality % distribution of *O. laevigatus* during its life time revealed that the survival curve of *O. laevigatus* females fed on *B. tabaci* infestation fit to Type II when reared on tomato and to Type III, when reared on eggplant according to Jervis and Copland (1996) classification of survival curves. Similar results about the survival Type of *O. laevigatus* were found by Tommasini *et al*. (2004) in which they reported that the survival curve of *O. laevigatus* females fitted to Type II when reared on *E. kuehniella* eggs at 22Cº and Type III at 30ºC.

In conclusion, our results showed that, the survival type of *O. laevigatus* is strongly affected by several factors including host plant (present study), prey species and temperature (Tommasini *et al*., 2004).

Consumption *of O. laevigatus*

Orius laevigatus nymphs were able to complete their developmental stages reaching to the adult stage, and become mature when fed on *B. tabaci* infestation offered on either tomato or eggplant. The consumption of *O. laevigatus* during its lifespan was higher with *B. tabaci* offered on tomato than on eggplant. The number of *B. tabaci* stages consumed by *O. laevigatus* was found to be correlated with the age of the predator.

Both adult males and females of *O. laevigatus* significantly preferred feeding on *B. tabaci* eggs rather than on larvae offered on either tomato or eggplant leaf discs (Tables 4 and 5). Also, the host plants showed a significant effect on the total and daily consumption of adult females of *O. laevigatus*, which was higher on tomato than on eggplant. However, in the case of *O. laevigatus* males, the host plant effect was statistically significant on the daily consumption but not on the total consumption and that could be due to the differences in the adult longevity of males on the two host plants which was 22.3 and 14days on tomato and on eggplant, respectively.

Comparing of the results with the finding of Tommasini *et al.* (2004) revealed that, when *O. laevigatus* nymphs were reared on *E. kuehniella* eggs or on *F. occidentalis* adults, *O. laevigatus* was higher in predation voracity of *B. tabaci* stages than that reported by Tommasini *et al.* (2004) on either *E. kuehniella* eggs or on *F. occidentalis* adults. In addition, correlation predation capacity with age of the predator was reported by Tommasini and Nicoli (1993). This increase in predation might be due to the raising in the searching activity of the third and fourth nymphs compared with the earlier stages (Tommasini and Nicoli, 1994; and Cocuzza *et al*., 1997).

As regards feeding preference of *O. laevigatus,* both nymphs and adults significantly preferred consumption of eggs than of larvae of *B. tabaci* reared on either tomato or eggplant. The results were in agreement with the findings by Hamdan (2006) who found that predatory bug *M. caliginosus* showed a significant preference to feed on the eggs of the greenhouse whitefly *T. vaporariorum* than on the larvae or pupae.

In conclusion, most lifecycle parameters of the predatory bug *O. laevigatus* were significantly affected by the host plant species of the prey (*B. tabaci)*. Thus rate of development, adult longevity, fecundity and rate of consumption were significantly higher when the *O. laevigatus* was predating on *B. tabaci* offered on tomato leaf discs than that on eggplant leaf discs. These results agreed to that found by Hamdan (2006) who reared *M. caliginosus* on greenhouse whitefly, *Trialeurodes vaporariorum*. Hamdan (2006) related that differences to the types of trichomes which lowered speeds of the predatory bug while searching on eggplant surfaces than that on tomato, thus the rate of consumption of predator was more when whitefly was offered on tomato than that offered on eggplant. Therefore, it can be drawn that host plant effect on the lifecycle parameters of the predator were related to the rate of consumption of whitefly stages when offered on each host plant species.

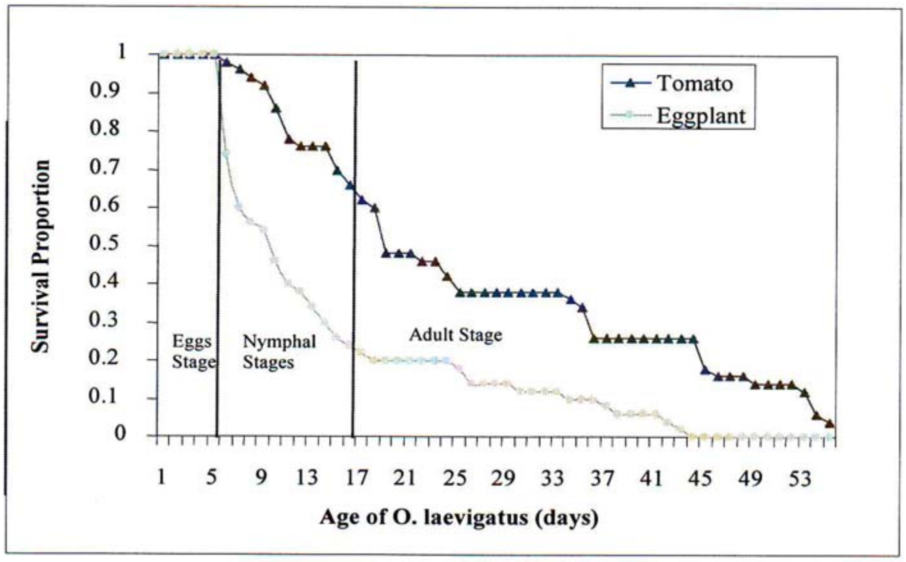

Fig. 1. Survival curves of *O. laevigatus* fed on *B. tabaci* infestation on either tomato or eggplant leaf discs.

Table 1. Duration of development and mortality % of *O. laevigatus* fed on *B. tabaci* infestation offered on either tomato or eggplant.

Orius Stage	Duration Of Development Days On ± SE (n*)			Distribution Of Mortality % During Each Nymph	
	Tomato	Eggplant	*P value*	Tomato	Eggplant
Eggs	4.26±0.06 (50)	4.30±0.07 (50)	0.66	-	-
N1	2.25±0.06 (48)	2.43±0.09 (30)	0.11	4	40
N2	2.10±0.04 (46)	2.07±0.05 (27)	0.62	4	6
N3	2.05±0.03 (38)	2.25±0.09 (20)	0.08	16	14
N4	2.60±0.08 (38)	2.22±0.10 (18)	0.005**	0	4
N5	3.46±0.09 (30)	4.70±0.15 (10)	0.001**	16	16
Total (Egg-Adult)	16.76±0.14 (30)	17.50±0.26 (10)	0.032**	40	80

* = n: number of replications (survived bug till end of each stage)

**= With significant effect of host plants duration of development at $P \leq 0.05$ using paired T-test analysis.

Table 2. Adult longevity of *O. laevigatus* (days) fed on *B. tabaci* infestation offered on different host plants.

Adult Longevity On ± SE (n*)			
Host Plant	Tomato	Eggplant	*P value*
Adult longevity of males	22.33±4.45 (9)	14.00±2.48 (6)	0.13
Adult longevity of females	25.6± 2.7 (15)	15.00±2.97 (4)	0.029**
Pre-oviposition period	1.0±0.0 (15)	1.0±0.0 (4)	1.0
Oviposition period	18.33±1.24 (15)	12.75±1.93 (4)	0.059
Post oviposition period	7.20±1.98 (15)	2.25± 1.31 (4)	0.055

* = n: number of replications (adult *O. laevigatus*).

** = With significant effect of host plants on adult longevity *at* $P \leq 0.05$ using paired T-test analysis.

Table 3. Total number of nymphs hatched per each *O. laevigatus* female when fed on *B. tabaci* infestation offered on different host plants.

Host plant	*Number of O. laevigatus* females	Total nymphs hatched / Female Mean ± SE	Daily nymphs hatched / Female ± SE
Tomato	15	71.47±4.79	3.99±0.15
Eggplant	4	30.25±4.01	2.56±0.19
P value		0.0001*	0.0001*

* = With significant effect of host plants on number of nymphs hatched / *Orius* female *at* $P \leq 0.05$ using paired T-test analysis.

Table 4. Total consumption of *O. laevigatus* nymphs fed on *B. tabaci* infestation offered on different host plants.

O .laevigatus nymphal instar	Prey	Total Consumption On ± SE (n*)		
	B. tabaci	Tomato	Eggplant	*P value*
N1	Eggs	40.08±1.09(48)	40.10±1.62(30)	0.99
	Larvae	4.06±0.44(48)	4.13±0.26(30)	0.89
	P value	0.001***	0.001***	
	E+L	44.15±1.16(48)	44.23±1.70(30)	0.97
N2	Eggs	41. 56±0.81(46)	34.03±0.75(27)	0.001**

O .laevigatus nymphal instar	Prey	Total Consumption On ± SE (n*)		
	B. tabaci	Tomato	Eggplant	*P value*
	Larvae	3.65±0.19(46)	3.59±0.17(27)	0.82
	P value	0.001***	0.001***	
	E+L	45.21±0.78(46)	37.63±0.72(27)	0.001**
N3	Eggs	45.34±0.80(38)	39.70±0.88(20)	0.001**
	Larvae	3.68±0.23(38)	5.60±0.49(20)	0.002**
	P value	0.001***	0.001***	
	E+L	49.02±0.82(38)	45. 30±1.15(20)	0.012**
N4	Eggs	77.28±0.95(38)	41.83±1.44(18)	0.001**
	Larvae	8.28±0.31(38)	4.72±0.48(18)	0.001**
	P value	0.001***	0.001***	
	E+L	85. 58±1.03(38)	46.44±1.79(18)	0.001**
N5	Eggs	121.27±1.31(30)	99.80±2.01(10)	0.001**
	Larvae	19.47±1.20(30)	9.90±0.60(10)	0.001**
	P value	0.001***	0.001***	
	E+L	140.73±1.71(30)	109.70±2.43(10)	0.001**
Total consumption/ all nymphs	Eggs	325. 53±15.2(30)	255.46±15.1(10)	0.001**
	Larvae	39.15±2.16(30)	28±1.82 (10)	0.001**
	P value	0.001***	0.001***	
	E+L	364.68±17.1(30)	283.46±16.8(10)	0.001**
Total consumption/ Adult male	Eggs	686±148(9)	374.7±80.1(6)	0.092
	Larvae	58.8±16.4(9)	27.17±5.51(6)	0.10
	P value	0.0030***	0.0075***	
	E+L	745±164(9)	401.8±85.4(6)	0.092
Total consumption/ Adult female	Eggs	817.9±96.9(15)	423. 5±94.7(4)	0.016**
	Larvae	65. 33±7.63(15)	31.75±7.40(4)	0.010**
	P value	0.001***	0.0062***	
	E+L	883±104(15)	455±102(4)	0.015**

* = n: number of replications (survived bug till end of each stage)

** = With significant effect of host plants on bug consumption *at* $P \leq 0.05$ using paired T-test analysis.

*** = With significant of prey stages bug consumption *at* $P \leq 0.05$ using paired T-test analysis.

Table 5. Daily consumption of *O. laevigatus* nymphs fed on *B. tabaci* infestation offered on different host plants.

O. laevigatus stage	Prey	Daily Consumption on ± SE (n*)		
	B. tabaci stage	Tomato	Eggplant	*P value*
N1	Eggs	18.14±0. 50(48)	16. 54±0. 31(30)	0.008**
	Larvae	1.86±0.22(48)	1.72±0.11(30)	0.57NS
	P value	0.001***	0.001***	
	E+L	20.01±0.56(48)	18.23±0. 30(30)	0.007**
N2	Eggs	20.06±0.53(46)	16. 59±0.47(27)	0.001**
	Larvae	1.76±0.10(46)	1.75±0.09(27)	0.91NS
	P value	0.001***	0.001***	
	E+L	21.83±0.54(46)	18. 34±0.47(27)	0.001**
N3	Eggs	22.25±0.47(38)	18.18±0.76(20)	0.001**

***O. laevigatus* stage**	**Prey**	**Daily Consumption on ± SE (n*)**		
	***B. tabaci* stage**	**Tomato**	**Eggplant**	***P value***
	Larvae	1.79±0.11(38)	2. 55±0.23(20)	0.007**
	P value	0.001***	0.001***	
	E+L	24.05±0.48(38)	20.73±0.899(20)	0.003**
N4	Eggs	30.94±1.18(38)	19.25±0.87(18)	0.001**
	Larvae	3.28±0.15(38)	2.14±0.23(18)	0.001**
	P value	0.0001***	0.0001***	
	E+L	34.23±1.27(38)	21.35±1.02(18)	0.001**
N5	Eggs	35. 59±0.85(30)	21.45±1.10(10)	0.001**
	Larvae	5.65±0. 31(30)	2.13±0.14(10)	0.001**
	P value	0.001***	0.001***	
	E+L	41.25±0.93(30)	23.67±1.20(10)	0.001**
Daily consumption/ all nymphs	Eggs	23.99±0. 54(30)	17. 35±0. 38(10)	0.001**
	Larvae	2.67±0.12(30)	1.93±0.09(10)	0.001**
	P value	0.001***	0.001***	
	E+L	26.67±0.62(30)	19.27±0.42(10)	0.001**
Daily cons/ Adult male	Eggs	32.62±0.87(9)	25.14±0.44(6)	0.001**
	Larvae	2.50±0.27(9)	1.87±0.11(6)	0.059
	P value	0.001***	0.001***	
	E+L	35.12±0.98(9)	27.02±0.45(6)	0.001**
Daily consumption/ Adult female	Eggs	32.99±0. 59(15)	25.78±0.29(4)	0.001**
	Larvae	2.67±0.06(15)	1.80±0.07(4)	0.001**
	P value	0.001***	0.001***	
	E+L	35.67±0.60(15)	27.68±0.26(4)	0.001**

* = n: number of replications (survived bug till end of each stage)

** = With significant effect of host plants on bug consumption *at* $P \leq 0.05$ using paired T-test analysis.

*** = With significant effect of prey stages on bug consumption *at* $P \leq 0.05$ using paired T-test analysis.

REFERENCES

Abu Awad, I. 2006. Laboratory study on the predator-prey relationship between thr predatory bug, *Orius laevigatus* (Fiber) [Hemiptera: Anthocoridae] and the tobacco whitefly, *Bemisia tabaci* (Gennadius) [Homoptera: Aleyrodidae]. M. Sc Thesis, Hebron University, Palestine.

Alauzet, C., Dargagnon, D., and Malausa, J. C. 1994. Bionomics of a polyphagous predator: *Orius laevigatus* (Heteroptera: Anthocoridae). *Entomophaga*, 39: 33-40

Berlinger, M. J. 1986. Host plant resistance to *Bemisia tabaci*. *Ecosystems Environment* 17: 69-82.

Breene, R. G. 1992. A new approach for matching biological control agents to pests. *IPM Practitioner* 14: 1-9.

Breene, R. G., Dean, D. A., and Quarles, W. 1994. Predators of sweetpotato whitefly. *IPM Practitioner*, 16:1-9.

Cocuzza, G. E., De Clercq, P., Lizzio, S., Van De Veire, M., Tirry, L., Degheele, D., and Vacante, V. 1996. Reproduction of *Orius laevigatus* and *Orius albidipennis* on Pollen and *Ephestia kuehniella* Eggs. *Entomologia Experimentalis et Applicata* 82: 101-104.

Cocuzza, G. E., De Clercq, P., Lizzio, S., Van De Veire, M., Tirry, L., Degheele, D., and Vacante, V. 1997. Life Tables and Predation Activity of *Orius laevigatus* and *O. albidipennis* at Three Constant Temperatures. *Entomologia Experimentalis et Applicata* 85: 189-198.

Cohhen, S., and Berlinger, M. J. 1986. Transmission and cultural control of whitefly born viruses. *Agricultural Ecosystem and Environment* 17: 89-97.

Gerling, D. 1986. Natural Enemies of *Bemisia Tabaci*, Biological Characteristics and Potential as Biological Control Agents: a review. *Agriculture, Ecosystems and Environment,* 17: 99-110.

Gerling, D. 1990. Natural Enemies of Whiteflies: Predators and Parasitoids. In: Gerling, D. (ed.) Whiteflies: *Their Bionomics, Pest Status and Management*, Intercept Ltd., Andover Hants. P. 147-185.

Gerling, D. 1996. Status of *Bemisia Tabaci* in the Mediterranean Countries: Opportunities for Biological; Control. *Biological Control* 6: 11-22.

Greathead, A. H. 1986. Host plant, In: Cock MJ (ed.) *Bemisia tabaci*: A Literature Survey on the Cotton Whitefly with an Annotated Bibliography. *International Institute of Biological Control*, Chamaleon Press, 17-25.

Hamdan, A. J. S. 2006. Effect of host-plant on the survival, adult longevity and fertility of predatory bug, *Macrilophus caliginosus* Wagner [Hemiptera: Miridae]. *Hebron University Research Journal* 2(2): 1-15.

Hamdan, A. J. S. 1997. Biological and Ecological Studies on the Predatory Bug *Macrolophus Caliginosus* Wagner as a Bio-control Agent Against The Green House Whitefly *Trialeurods vaporariorum* (Weestwood), Ph.D Thesis, University of London.

Hamon, A. B., and Salguero, V. 1987. *Bemisia tabaci*, Sweetpotato Whitefly, in Florida (Homoptera: Aleyrodidae: Aleyrodinae). *Entomology Circular* No. 292. Fla. Department. Agricultural and Consumer Services., Division of Plant Industry.

Henneberry, T. J., Toscano, N. C., Faust, R. M., Coppedge, J. R. (Eds.) 1994. Silverleaf whitefly (formerly sweetpotato whitefly). *National Research Action Plan* 2: 124-125.

Hoelmer, K. A., Osborne, L. S., and Yokomi, R. K. 1991. Foliage Disorder in Florida Associated with Feeding by Sweetpotato Whitefly, *Bemisia Tabaci*. *Florida Entomologist* 74: 162-166.

Hoelmer, K. A., Osborne, L. S., and Yokomi, R. K. 1993. Reproduction and Feeding Behavior of *Delphastus pusillus* (Coleoptera: Coccinellidae), a Predator of *Bemisia tabaci* (Homoptera: Aleyrodidae). *Journal of Eeconomic Entomology* 86: 322-329.

Hoelmer, K. A., Osborne, L. S., and Yokomi, R. K. 1994. Interaction of the Whitefly Predator *Delphastus pusillus* (Coleoptera: Coccinellidae) with Parasitized *Bemisia tabaci* (Homoptera: Aleyorodidae). *Environmental Entomology* 23: 136-139.

Jervis, M.A., and Copland, M. J. W. 1996. The Life Cycle. In: Jervis M, Kidd N (eds.). *Insect Natural Enemies: Practical Approaches to their Study and Evolution*. Chapman and Hall Ltd., London. P. 63-162.

Kring, J. B., Schuster, D. J., Price, J. F., and Simone, G. W. 1991. Sweetpotato whitefly vectored Geminivirus on Tomato in Florida. *Plant Disease* 75: 1186.

Mustafa- Al-Antary, T. and Al-Momany, A. 1990. Pests of Garden and Home. Dar Al-arabiah for Publication and Distribution, Cairo,.390.

PCBS, 2006. Agricultural Statistics. Palestinian Central Bureau of Statistics, Ramallah, Palestine.

Polston, J. E., Hiebert, E., McGovern, R. J., Stansly, P. A., and Schuster, D. J. 1993. Host Range of Tomato Mottle Virus, a New Geminivirus Infecting Tomato in Florida. *Plant Disease,* 77: 1181-1148.

Riudavets, J. 1995. Predators of *Frankliniella occidentalis* (Perg.) and *Thrips tabaci* Lend. *Wageningen Agriculture University Papers* 95: 43-87.

Schuster, D. J., Kring, J. B., and Price, J. F. 1991. Association of the sweetpotato whitefly with a silverleaf disorder of squash. *Horticulture science,* 26: 155-156.

Tommasini, M. G., and Nicoli, G. 1993. Adult activity of four *Orius* species reared on two preys. *International Organization for Biological Control, West Palaearctic Regional Section Bulletin* 16: 181–186.

Tommasini, M. G., and Nicoli, G. 1994. Pre-imaginal activity of four *Orius* species reared on two preys. *International Organization for Biological Control, West Palaearctic Regional Section Bulletin* 17: 237–241.

Tommasini, M. G., Joop, C., Lenteren, V., and Burgio, G. 2004. Biological traits and predation capacity of four *Orius* species on two prey species. *Bulletin of Insectology* 57: 79-78.

Tommasini, M. J., and Maini, S. 2001. Thrips control on protected sweet pepper crops: enhancement by means of *Orius laevigatus* releases. *Wageningen Agricultural University Papers* 95: 249- 256.

Zaki, F. N. 1989. Rearing of two predators, *Orius albidipennis* (Reut.) and *Orius laevigatus* (Fieber) (Hem: Anthocoridae) on some insect larvae. *Journal of Applied Entomology* 107: 107–109.

دورة حياة البق المفترس Orius laevigatus (Fiber) [Hemiptera: Anthocoridae] في حالة تغذيته على آفة ذبابة التبغ البيضاء Bemisia tabaci (Gennadius) [Homoptera: Aleyrodidae] المنتشرة على نباتات البندورة والخيار

*عبد الجليل سالم حمدان وإياد طالب ابو عوض **

ملخـص

تشتمل الدراسة على فحوصات مخبرية لدورة حياة البق المفترس *O. laevigatus* عند تغذيته على ذبابة التبغ البيضاء مقدمة على أوراق نباتات البندورة والباذنجان تحت الظروف المخبرية الثابتة (25 ± 1ºC, 75 ± 5% R. H. and 16 L: 8 D). ولقد وجد أن الحوريات والحشرات البالغة من البق المفترس لديها القدرة على افتراس بيوض، ويرقات الذبابة البيضاء المقدمة على أوراق البندورة والباذنجان، كما وجد أن حشرات البق المفترس تفضل التغذية على بيوض الذبابة البيضاء أكثر منه على اليرقات. وأن معدل الافتراس من الذباب الأبيض المقدم على أوراق البندورة كان أعلى منه على أوراق الباذنجان، حيث إن مجموع الافتراس خلال مراحل تطور حوريات البق المفترس كان 364.7 و283.5 من بيوض ويرقات الذباب الأبيض المقدمة على أوراق البندورة والباذنجان على التوالي. كما وجد أيضاً أن إناث البق المفترس البالغة تفترس ما مجموعه 883 و445 من بيوض ويرقات الذبابة البيضاء المقدمة على أوراق البندورة، والباذنجان على التوالي. وبالتالي فإن فترة حياة البق المفترس كانت أطول في حال تغذيتها على الذباب الأبيض المقدم على أوراق البندورة منها على أوراق الباذنجان، كما أن معدل الخصوبة للبق المفترس كان أعلى في حالة تغذيته على الذبابة البيضاء المقدم على أوراق البندورة منها على أوراق الباذنجان. وقد وجد أن نمط البقاء (Survival Type) للبق المفترس كان من النوع الثاني (Type II) في حالة التغذية على الذباب الأبيض المقدم على أوراق البندورة، في حين كان النمط من النوع الثالث (Type III) على أوراق الباذنجان. وبذلك يمكن الاستنتاج بان كلاً من معدل الافتراس ومعدل الخصوبة للبق المفترس يتأثر بالعائل النباتي للفريسة، وبناء عليه فإننا نوصي بإجراء دراسات حول استخدام البق المفترس *O. laevigatus* للمكافحة الحيوية للذبابة البيضاء على محاصيل البندورة والباذنجان.

الكلمـات الدالـة: ذبابة التبغ البيضاء، البق المفترس، حشرة النباتات.

* قسم الإنتاج النباتي والوقاية، كلية الزراعة، جامعة الخليل، الخليل، فلسطين. تاريخ استلام البحث 2007/10/22، وتاريخ قبوله 2008/2/26.