Arab Universities Journal of Agricultural Sciences
(2022) 30 (2) 1-8
Website: http://ajs.journals.ekb.eg

Evaluation of *Orius laevigatus* as a predator of *Bemisia tabaci* in Vitro

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DOI: 10.21608/AJS.2022.128874.1474

Received 30 March 2022 ; Accepted 23 June 2022

Keywords:

Biocontrol agent, *Orius laevigatus*, *Bemisia tabaci*, Predation capacity, Prey density, Predator–prey

Abstract: This study determined the ability of *Orius laevigatus* to consume different stages of *Bemisia tabaci* at various densities. Additionally, the use of *B. tabaci* as food and its effect on the life cycle parameters and female fecundity of *Orius* predator developmental stages were investigated. The results showed that *O. laevigatus* could consume whitefly at various stages and complete its preimaginal and postimaginal stages, with *B. tabaci* eggs, nymph instars, and adults as the only available food source. The consumption and fecundity of *O. laevigatus* were influenced by feeding on different stagesof *B. tabaci*. Furthermore, the females of this predator consumed more eggs, fourth nymphal instar, and adults than the first, second, and third instar nymphs of *B. tabaci* on a different density level. The mean numbers of consumptions at different stages of *B. tabaci* increased with increasing prey densities. The result simply that *O. Laevigatus* can be used as a predator in the biological control of tobacco whiteflies.

1 Introduction

Bemisia tabaci (Genn.) (Homoptera: Aleyrodidae) is distributed globally (De Barro et al 2000 & 2005, Sani et al 2020) and nourished by plant sap and secretions. Spreading has a severe impact on crop quality and quantity, resulting in the rapid growth of whiteflies and molds (Colvin et al 2006, Prijovic et al 2013). *B. tabaci* is a vector of over 300 viral species in various economically important agricultural crops (Gilbertson et al 2015). Chemical pesticides are ineffective at controlling tobacco whiteflies and contribute to pesticide resistance. Biological control agents, such as predators and parasitoids, are considered a great alternative in *B. tabaci* control (Gerling et al 2001). Biological control of *B. tabaci* was first used 14 years ago, and many attempts have been successful. Although biological control of whiteflies through predators is an effective strategy, its potential has been widely ignored in numerous agricultural systems (ALzyoud 2014).

The genus *Orius* has many polyphagous species considered as predators, with a preference for attacking thrips nymphs and adults, spider mites, and whiteflies (Yamada et al 2016, Zhao et al 2017, El Kenway et al 2021). *O. laevigatus* (Hemiptera: Anthocoridae) was particularly effective in the biological control strategy (Chambers et al 1993, Sanchez and Lacasa 2002, Coll et al 2007). Thus, *O. laevigatus* is considered one of the most efficient predators and has been successfully used in greenhouse biocontrol programs. Daily prey consumption and numerical responses of *O. laevigatus* to different crop pests have demanding study requirements for controlling and decreasing these pests' densities on various crops (Shahpouri et al 2019, Pehlivan et al 2020, El Kenway et al 2021). Furthermore, this predator was used in open-field cropping systems against various Thysanoptera pests and whiteflies (Chambers et al 1993). This study aims to investigate the biological characteristics, including the development, reproduction, and feeding capacity, of *O. laevigatus* in vitro, to introduce it as a biological control agent in integrated pest management.

2 Materials and Methods

2.1 Rearing *B. tabaci* on tomato plants

B. tabaci was obtained from the Syngenta Kaha research station to establish a stock culture in the Central Lab. of Organic Agriculture and was introduced onto tomato plants in wooden cages (dimension: 90 × 90 × 90 cm) with upper opening and sides covered with white muslin for ventilation. To obtain the culture of the whitefly, healthy tomato transplants were inserted in between the infested plants kept in the wooden cages. After 48 h, the freshly infested transplants were transferred to new wooden cages and kept under *in vitro* conditions (25°C–30°C and 65%–75% relative humidity [RH]) to be used as fresh leaf disks infested with eggs and nymphs of *B. tabaci* for the *O. laevigatus* predators to consume daily.

2.2 Effect of different *B. tabaci* stages on life cycle parameters of *O. laevigatus*

Experiments were conducted in vitro (25°C ± 2°C, 65% ± 5% RH, and 16 L: 8 D photoperiod).

2.2.1 Rearing of *O. laevigatus*

O. laevigatus was obtained from the Biological Control Department (Plant Protection Research Institute) in a plastic container, containing 500 individuals. Additionally, 18% of them were at fifth instar nymph, and the rest were newly emerged adults. They were provided with sawdust as carriers to prevent cannibalism and improve ventilation. Adults and nymphs of *O. laevigatus* were kept in 10 × 20 cm diameter plastic jars covered with muslin. These jars were provided with small pieces of sawdust to reduce cannibalism, and tomato disks infested with *B. tabaci* were provided as a source of nutrition for the predator. A piece of bean pod (*Phaseolus vulgaris*), 3 cm in diameter, was used as an ovipositional substrate in each jar. Eggs were inserted into the bean pod tissue. The bean pods, which contained eggs, were removed daily and placed in plastic jars to be examined daily until they hatched. The newly hatched first instar nymphs were moved to another jar containing tomato disks infested with *B. tabaci* as a food source.

2.2.2 Developmental durations of immature stages of *O. laevigatus* on *B. tabaci*

The life history parameters of the nymphs and adults were investigated. Approximately 360 newly hatched first instar *O. laevigatus* nymphs (60 nymphs were used for each *B. tabaci* stage [eggs; first, second, third, and fourth instars of nymphs; and adults]) were collected from the bean pods in the plastic jars. Each nymph was reared individually in a Petri dish (5cm diameter) on infested tomato leaf disks with *B. tabaci*. The nymphs were provided daily with fresh tomato disks infested with five *B. tabaci* at each stage. The duration and consumption of each instar nymph, egg, female, and male were estimated daily. The life cycle parameters of *Orius* instar nymphs were assessed via daily observation during their nymphs' development. Once they molted to become an adult, each adult of *O. laevigatus* was sexed to ensure mating. After mating, each male and female were reared separately to record the daily and total consumption (Isenhour and Yeargan 1981).

2.3 Fecundity and longevity of *O. laevigatus* females

Orius adults that newly emerged were collected from the stock culture and reared on a diet of *B. tabaci*. Males and females were paired and kept in a 10cm Petri dish. Females were fed new tomato disks infested with different stages of *B. tabaci* (eggs; first, second, third, and fourth instars of nymphs; and adults) daily, along with pieces of bean bods as an ovipositional substrate. A total of 108 *Orius* adults, 18 for each treatment and six for each replicate (three replicates for each treatment), were observed daily for preoviposition, oviposition, and postoviposition periods in each replicate. During the oviposition period, the bean pods with *O. laevigatus* eggs were collected daily, counted, and put in Petri dishes until they hatched in the incubator at 25°C ± 2°C, 65% ± 5% RH. After they hatched, the number of progeny /female/day was recorded. Preoviposition, postoviposition, and oviposition periods; fecundity; and male and female longevities were also examined.

2.4 *O. laevigatus* predation capacity on *B. tabaci* at different densities

The predatory ability of the developmental stages (first, second, third, fourth, and fifth instar of nymphs, males, and females) of *O. laevigatus* that fed on eggs; first, second, third, and fourth instars of nymphs; and adults of *B. tabaci* at various densities (5, 10, 15, 20, 25, 30, and 35 individuals) was assessed at 25°C ± 2°C, 65% ± 5% RH, and 18:6 photoperiod.

2.5 Statistical analysis

Data were analyzed using the ANOVA test, and the SAS statistical package was used to compare means using the LSD at a *p*-level of 0.05 (SAS Institute 2006).

3 Results and Discussion

3.1 Effect of different stages of *B. tabaci* as food on the life cycle development of *O. laevigatus*

In these experiments, the effect of different *B. tabaci* stages was investigated when used as food during incubation periods for the eggs, instars of nymph, and adults of *O. Laevigatus* at 65%± 5% RH, 25°C ± 2°C, and a 16 L: 8 D photoperiod.

3.1.1 Duration of *O. laevigatus* immature stages

Statistical analysis revealed that the incubation periods of *O. laevigatus* were 4.37; 4.56, 3.67, 3.17, and 2.73; and 3.04 days when the predator fed on *B. tabaci* eggs; first, second, third, and fourth instars of nymphs; and adults, respectively **(Table 1)**.

The results also showed that eating tobacco whiteflies at different ages affected different nymph age periods and the overall nymph age period of *O. laevigatus*. For example, the shortest total nymph duration of the predator was 11.75 days when it fed on the whitefly adult, whereas the longest occurred when it fed on the first and second instars of nymphs **(Table 1)**. Rehman et al (2020) similarly cited the duration of eggs and nymphs of *O. strigicollis* when the predator consumed *B. tabaci* at 25°C ± 1°C, 75% ± 5% RH, and a 16 L:8 D photoperiod.

3.1.2 Duration of *O. laevigatus* male and female

The longevities of male and female predators were recorded at the lowest period of 17.66 and 23.63 days when being fed *B. tabaci* eggs and adults, respectively. Conversely, the longest duration for males and females was 18.70 and 26.20 days when consumingthe first and second instars of *B. tabaci* nymph, respectively. Additionally, statistical analysis showed significant differences in female and male longevities at a *p*-value of <0.05% **(Table 2)**.

Furthermore, the results revealed that feeding on *B. tabaci* had a significant effect on predatorsat different stages in the postoviposition and oviposition periods of the *O. laevigatus* female, whereas it was insignificant for the preoviposition period **(Table 2)**. These data agreed with the findings of Rehman et al (2020), who discovered that *O. strigicollis* fed on *B. tabaci* or *Trialeurodes vaporariorum* under laboratory conditions (28°C ± 1°C temperature, 70% ± 5% RH, and a 16 L:8 D photoperiod at a light intensity of 1400–1725 lux.).

3.2 Female fecundity

The daily and the total number of eggs, as well as the total hatched eggs per female, were higher when they were fed older *B. tabaci* compared with younger ones. Female daily egg numbers of *O. laevigatus* were 3.50; 5.03, 5.70, 6.07, and 6.03; and 6.73 eggs when fed whitefly eggs; first, second, third, and fourth instars of nymphs; and adults, respectively. The stages of *B. tabaci* had a significantly high effect on the total number of eggs and hatched eggs for each female *Orius* but a significantly low effect on the total percentage of eggs hatched per female **(Table 3)**.

Rehman et al (2020) studied the fecundity of *O. strigicollis* female after rearing on *B. tabaci* or *Trialeurodes vaporariorum* under laboratory conditions (28°C ± 1°C, 70% ± 5% RH, and a 16 L: 8 D photoperiod); following the study, less number of eggs than that in this study was recorded. Cocuzza et al (1997a) also reported that *O. laevigatus* fecundity averages were 183.7, 187.9, and 79.2 eggs per female when they consumed the Mediterranean flour moth eggs, pollen + the Mediterranean flour moth eggs, and pollen only, respectively, at 23°C and 60% ± 5% RH. Alauzet et al (1994) recorded that the average *O. laevigatus* female fecundity was 145, 239, 166, and 141 eggs per female at 15°C, 20°C, 25°C, and 30°C, respectively.

Table 1. Duration of different developmental stages of *O. laevigatus* when preyed on different *B. tabaci* stages

Duration/day of *O. laevigatus* stage	*B. tabaci* stages						F	P	LSD
	Eggs	First nymph	Second nymph	Third nymph	Fourth nymph	Adult			
Eggs	4.37^{ab}	4.56^{a}	3.67^{bc}	3.17^{cd}	2.73^{d}	3.04^{cd}	16.43	0.000	0.79
1st instar	2.30^{b}	2.60^{a}	2.26^{bc}	2.26^{bc}	2.00^{c}	2.16^{bc}	6.86	0.000	0.27
2nd instar	2.46^{b}	2.83^{a}	2.70^{a}	2.68^{a}	2.5^{b}	2.24^{b}	5.33	0.000	0.3
3rd instar	2.30^{b}	3.00^{a}	3.00^{a}	2.80^{a}	2.30^{b}	2.46^{b}	22.92	0.000	0.25
4th instar	2.50^{a}	2.63^{a}	2.60^{a}	2.43^{a}	2.50^{a}	2.50^{a}	0.64	0.660	0.33
5th instar	2.83^{ab}	3.00^{a}	3.00^{a}	2.67^{b}	2.73^{b}	2.73^{b}	4.77	0.000	0.24
Total nymphal stage	12.32^{bc}	13.79^{a}	13.55^{a}	12.72^{b}	12.02^{cd}	11.75^{d}	52.00	0.000	0.49

F, P, and LSD values on <0.05%
Mean, within a row, bearing different subscripts are significantly different

Table 2. *O. laevigatus* adult duration (days) when preyed on different *B. tabaci* stages

Duration/day of *O. laevigatus*	*B. tabaci* stages						F	P	LSD
	Eggs	First instar	Second instar	Third instar	Fourth instar	Adult			
Male	17.66^{b}	18.70^{a}	18.30^{ab}	17.83^{ab}	18.06^{ab}	18.36^{ab}	2.35	0.043	0.9
Female	24.80^{b}	24.86^{b}	26.20^{a}	25.10^{ab}	25.40^{a}	23.63^{c}	7.69	0.000	1.11
Preoviposition	1.15^{a}	1.26^{a}	1.20^{a}	1.17^{a}	0.93^{a}	0.96^{a}	2.12	0.1300	0.39
Oviposition	4.50^{bc}	6.10^{a}	5.27^{b}	4.76^{bc}	4.23^{c}	4.20^{c}	16.56	0.0001	0.77
Postoviposition	18.88^{bc}	17.20^{d}	19.66^{ab}	19.13^{bc}	20.27^{a}	18.46^{c}	21.9	0.0000	0.97

F, P, and LSD values on <0.05%
Mean, within a row, bearing different subscripts are significantly different

Table 3. *O. laevigatus* female fecundity when reared on *B. tabaci* eggs, nymphs, and adults

O. laevigatus female	*B. tabaci* stages						F	P	LSD
	Eggs	First instar	Second instar	Third instar	Fourth instar	Adult			
Eggs/female/day	3.50^{d}	5.03^{c}	5.70^{bc}	6.07^{ab}	6.03^{ab}	6.73^{a}	33.14	0.0000	0.85
Total eggs/female	65.87^{c}	86.59^{b}	112.09^{a}	116.07^{a}	122.27^{a}	126.30^{a}	43.92	0.0000	15.18
Total eggs hatched/female	59.06^{d}	77.98^{c}	102.92^{b}	103.31^{b}	109.41^{ab}	113.87^{a}	87.67	0.0000	9.84
Total eggs hatch %/female	90.07^{abc}	90.06^{abc}	91.89^{a}	89.42^{c}	89.62^{bc}	91.60^{ab}	4.53	0.0100	2.11

F, P, and LSD values on <0.05%
Mean, within a row, bearing different subscripts are significantly different

3.3 Feeding capacity of *O. laevigatus* on different *B. tabaci* stages

The daily consumption of *B. tabaci* eggs, nymphs, and adults by *Orius laevigatus* nymphs, females, and males was recorded at 25°C ± 2°C and 65% ± 5% RH. *B. tabaci* adults were the most favorable stage for the majority of *O. laevigatus* stages, except for the first nymph instar and males **(Table 4)**.

The average number of daily or total consumption by predators increased with the successive development of the predator nymph. Feeding the predator at different stages of *B. tabaci* significantly affected the total and daily consumption of *O. laevigatus* nymphs, females, and males but had an insignificant effect on the total consumption of *O. laevigatus* nymphal stage **(Tables 4 and 5)**.

Pehlivan et al (2020) reported that the females of *O. laevigatus and O. vicinus* were able to feed on *B. tabaci* or *T. urticae* eggs. The improved predation could be due to the increased foraging activity of the older nymphs than the younger ones (Cocuzza et al 1997 b).

Table 4. *O. laevigatus* nymphs/day of consumption reared on different whitefly stages

***O. laevigatus* stage**	***B. tabaci* stages**						**LSD 0.05**	**F value**	**P**
	Eggs	**1st instar**	**2nd instar**	**3rdinstar**	**4th instar**	**Adult**			
1st instar	0.86^{ab}	1.10^{a}	0.86^{ab}	0.79^{b}	0.62^{b}	0.65^{b}	0.3	5.98	0.005
2nd instar	1.80^{ab}	1.55^{c}	1.76^{abc}	1.65^{bc}	1.86^{ab}	1.87^{a}	0.21	6.43	0.004
3rd instar	2.25^{a}	1.88^{b}	2.15^{a}	1.90^{b}	2.21^{a}	2.24^{a}	0.17	16.56	0.000
4th instar	2.54^{b}	2.35^{b}	1.93^{c}	2.76^{a}	2.79^{a}	2.82^{a}	0.21	48.71	0.000
5th instar	3.56^{b}	3.34^{c}	3.05^{d}	3.39^{c}	3.60^{ab}	3.72^{a}	0.15	46.12	0.000
Female	4.31^{ab}	4.25^{ab}	4.08^{b}	4.06^{b}	4.53^{a}	4.37^{a}	0.29	7.06	0.003
Male	4.04^{a}	3.86^{ab}	3.65^{c}	3.70^{bc}	4.00^{a}	3.61^{c}	0.18	18.83	0.000

F, P, and LSD values on <0.05%
Mean, within a row, bearing different subscripts are significantly different

Table 5. *O. laevigatus* nymphs and adults total consumption preyed on different *B. tabaci* stages

Consumption of *O. laevigatus* stage	***B. tabaci* stages**						**LSD 0.05**	**F value**	**P**
	Eggs	**1st instar**	**2nd instar**	**3rd instar**	**4th instar**	**Adult**			
1st instar	1.98^{ab}	2.87^{a}	1.93^{ab}	1.76^{b}	1.26^{b}	1.39^{b}	0.98	6.26	0.0044
2nd instar	4.32^{b}	3.85^{c}	4.76^{a}	4.32^{b}	4.66^{a}	4.17^{bc}	0.32	16.07	0.0001
3rd instar	5.11^{cd}	5.53^{b}	6.43^{a}	5.27^{bcd}	5.05^{d}	5.37^{bc}	0.31	48.75	0.0000
4th instar	6.23^{c}	6.08^{c}	5.00^{d}	6.63^{ab}	6.62^{b}	6.99^{a}	0.36	67.3	0.0000
5th instar	8.89^{b}	9.08^{b}	9.77^{a}	9.98^{a}	10.02^{a}	10.08^{a}	0.43	26.05	0.0000
Total nymphal stage	27.68^{a}	28.27^{a}	27.37^{a}	26.89^{a}	27.37^{a}	28.01^{a}	1.41	2.3	0.1000
Female	105.39^{b}	103.62^{c}	105.60^{b}	101.8^{d}	115.09^{a}	105.71^{b}	1.32	225.41	0.0000
Male	70.51^{c}	70.97^{b}	66.43^{d}	64.41^{f}	71.52^{a}	65.70^{e}	0.33	1592.05	0.0000

F, P, and LSD values on <0.05%
Mean, within a row, bearing different subscripts are significantly different

3.4 Predatory capacity of different stages of *O. laevigatus* feeding on *B. tabaci* for 24 h under laboratory conditions

As presented in **Tables 6 and 7**, the amount of consumed prey increased significantly with increasing prey density, whereas the predator's consumption increased with an increase in the number of prey. The first and fifth instars of *O. laevigatus* nymphs preferred to consume *B. tabaci* eggs. Conversely, the second and fourth instars of *O. laevigatus* nymphs and females consumed more fourth instar nymphs than the other developmental stages of *B. tabaci*, and the third instar nymphs of the predator consumed more tobacco whitefly eggs and adults. *Orius* males preferred whitefly eggs and the fourth instar nymphs.

Furthermore, when fed different stages and densities of the tobacco whitefly, the predator's consumption of the immature stage compared with the different stages of *B. tabaci* could be arranged ascendingly as follows: first> second> third> fourth> and fifth instars, whereas female *O. laevigatus* consumed more prey than males. It was clear that there were considerable differences in the consumption rates of the different stages of *O. laevigatus* when they preyed on various densities of different *B. tabaci* stages.

Pehlivan et al (2020) studied the consumption ability of two *Orius* species' (*O. laevigatus* and *O. vicinus*) females when they preyed on different amounts of *B. tabaci* and *T. urticae* eggs. For the eggs of *B. tabaci*, both predators fed on more eggs when the densities of *B. tabaci* increased. Shahpouri et al (2019) discovered that when *Orius albidipennis* preyed on the eggs and third instar nymphs of *B. tabaci* at different densities (5, 8, 10, 15, 20, 25, 30, and 35), the amount of consumed prey considerably increased with an increased prey density of 5–25 eggs or nymphs, whereas the number of prey consumed was insignificant at densities greater than 25 eggs or nymphs.

Table 6. Predatory capacity of different ages of *O. laevigatus* on different densities of *B. tabaci* immature stages for 24 h

***O. laevigatus* nymphal stage**	***B. tabaci* stages**	***B. tabaci* densities**							**LSD 0.05**	**F value**	**P**
		5	**10**	**15**	**20**	**25**	**30**	**35**			
1st instar	Egg	0.86^{e}	1.67^{e}	3.56^{d}	4.80^{c}	5.73^{b}	6.73^{a}	7.30^{a}	0.81	160.09	0.000
	1stinstar	1.1^{g}	2.05^{f}	3.00^{e}	3.95^{d}	4.90^{c}	5.85^{b}	6.80^{a}	0.24	1263.5	0.000
	2ndinstar	0.86^{g}	1.70^{f}	2.54^{e}	3.38^{d}	4.22^{c}	5.06^{b}	5.9^{a}	0.37	423.36	0.000
	3rdinstar	0.79^{g}	1.59^{f}	2.39^{e}	3.19^{d}	3.99^{c}	4.79^{b}	5.59^{a}	0.18	1571.92	0.000
	4thinstar	0.62^{g}	1.36^{f}	2.10^{e}	2.84^{d}	3.58^{c}	4.32^{b}	5.06^{a}	0.16	1654.61	0.000
	Adult	0.65^{g}	1.29^{f}	1.93^{e}	2.57^{d}	3.21^{c}	3.85^{b}	4.49^{a}	0.36	253.36	0.000
2nd instar	Egg	1.8^{g}	3.32^{f}	5.04^{e}	6.66^{d}	8.28^{c}	9.90^{b}	11.52^{a}	0.64	524.88	0.000
	1stinstar	1.56^{g}	3.27^{f}	4.96^{e}	6.66^{d}	8.37^{c}	10.06^{b}	11.76^{a}	0.78	391.54	0.000
	2ndinstar	1.77^{g}	3.58^{f}	5.39^{e}	7.20^{d}	9.01^{c}	10.82^{b}	12.63^{a}	0.49	1099.88	0.000
	3rdinstar	1.64^{g}	3.35^{f}	5.06^{e}	6.77^{d}	8.48^{c}	10.19^{b}	11.90^{a}	0.35	1886.51	0.000
	4thinstar	1.86^{g}	3.67f	5.46e	7.27d	9.07c	10.86b	12.66a	0.37	1944	0.000
	Adult	1.71^{g}	3.60^{f}	5.42^{e}	7.21^{d}	9.00^{c}	10.82^{b}	12.60^{a}	0.49	1076.58	0.000
3rd instar	Egg	2.24^{g}	4.23^{f}	6.12^{e}	8.20^{d}	10.10^{c}	12.21^{b}	14.2^{a}	0.64	800	0.000
	1stinstar	1.83^{g}	3.68^{f}	5.53^{e}	7.38^{d}	9.23^{c}	11.08^{b}	12.93^{a}	0.37	2053.5	0.000
	2ndinstar	2.13^{g}	4.05^{f}	5.97^{e}	7.89^{d}	9.81^{c}	11.73^{b}	13.65^{a}	0.61	814.88	0.000
	3rdinstar	1.91^{g}	3.80^{f}	5.70^{e}	7.60^{d}	9.50^{c}	11.40^{b}	13.3^{a}	0.24	5054	0.000
	4thinstar	2.20^{g}	4.11^{f}	6.02^{e}	7.93^{d}	9.84^{c}	11.75^{b}	13.66^{a}	0.64	729.62	0.000
	Adult	2.23^{g}	4.30^{f}	6.42^{e}	8.53^{d}	10.62^{c}	12.71^{b}	14.83^{a}	0.61	974.84	0.000
4th instar	Egg	2.50^{g}	4.60^{f}	6.70^{e}	8.80^{d}	10.90^{c}	13.00^{b}	15.1^{a}	0.24	6174	0.000
	1stinstar	2.33^{g}	4.41^{f}	6.53^{e}	8.60^{d}	10.71^{c}	12.80^{b}	14.93^{a}	0.74	661.5	0.000
	2ndinstar	1.92^{g}	3.84^{f}	5.76^{e}	7.68^{d}	9.60^{c}	11.52^{b}	13.44^{a}	0.16	11138.76	0.000
	3rdinstar	2.54^{g}	5.06^{f}	7.46^{e}	9.85^{d}	12.25^{c}	14.66^{b}	17.00^{a}	0.5	1860.92	0.000
	4thinstar	2.76^{g}	5.26^{f}	7.76^{e}	10.23^{d}	12.76^{c}	15.24^{b}	17.76^{a}	0.61	1381.57	0.000
	Adult	2.60^{g}	5.10^{f}	7.61^{e}	10.10^{d}	12.60^{c}	15.10^{b}	17.60^{a}	0.24	8750	0.000
5thinstar	Egg	3.54^{g}	7.06^{f}	10.56^{e}	14.01^{d}	17.56^{c}	21.00^{b}	24.56^{a}	0.61	2707.89	0.000
	1stinstar	3.31^{g}	6.53^{f}	9.73^{e}	12.90^{d}	16.11^{c}	19.33^{b}	22.53^{a}	0.74	1536	0.000
	2ndinstar	3.10^{g}	5.93^{f}	8.80^{e}	11.73^{d}	14.61^{c}	17.50^{b}	20.41^{a}	0.37	5046	0.000
	3rdinstar	3.37^{g}	6.44^{f}	9.56^{e}	12.65^{d}	15.76^{c}	18.87^{b}	21.96^{a}	0.37	5766	0.000
	4thinstar	3.61^{g}	6.63^{f}	9.57^{e}	12.62^{d}	15.61^{c}	18.59^{b}	21.60^{a}	0.42	4200	0.000
	Adult	3.70^{g}	6.50^{f}	9.30^{e}	12.10^{d}	14.90^{c}	17.70^{b}	20.50^{a}	0.48	2744	0.000

F, P, and LSD values on <0.05%

Mean, within a row, bearing different subscripts are significantly different

Table 7. Predatory capacity of different stages of *O. laevigatus* on *B. tabaci* female and male different densities for 24h

***O. laevigatus* adult**	***B. tabaci* stages**	***B. tabaci* densities**							**LSD 0.05**	**F value**	**P**
		5	**10**	**15**	**20**	**25**	**30**	**35**			
Female	Egg	4.31^{g}	8.42^{f}	12.51^{e}	16.62^{d}	20.70^{c}	24.81^{b}	28.90^{a}	0.48	5883.5	0.000
	1^{st} instar	4.22^{g}	8.32^{f}	12.42^{e}	16.51^{d}	20.62^{c}	24.72^{b}	28.82^{a}	0.59	3975.33	0.000
	2^{nd} instar	4.03^{g}	7.70^{f}	11.42^{e}	15.13^{d}	18.81^{c}	22.50^{b}	26.23^{a}	0.37	8214	0.000
	3^{rd} instar	4.01^{g}	7.57^{f}	11.06^{e}	14.51^{d}	18.06^{c}	21.56^{b}	25.10^{a}	0.28	12862.5	0.000
	4^{th} instar	4.40^{f}	8.63^{f}	12.71^{e}	16.81^{d}	20.93^{c}	25.03^{b}	29.13^{a}	0.74	2521.5	0.000
	Adult	4.43^{g}	8.40^{f}	12.16^{e}	16.26^{d}	20.40^{c}	24.41^{b}	28.47^{a}	0.61	3536.84	0.000
Male	Egg	4.01^{g}	7.80^{f}	11.60^{e}	15.43^{d}	19.23^{c}	23.02^{b}	26.83^{a}	0.37	8664	0.000
	1^{st} instar	3.82^{g}	7.41^{f}	11.03^{e}	14.60^{d}	18.13^{c}	21.82^{b}	25.41^{a}	0.85	1471.13	0.000
	2^{nd} instar	3.61^{g}	7.13^{f}	10.54^{e}	14.13^{d}	17.61^{c}	21.13^{b}	24.60^{a}	0.92	1196.51	0.000
	3^{rd} instar	3.61^{g}	7.04^{f}	10.42^{e}	13.84^{d}	17.25^{c}	20.61^{b}	24.05^{b}	0.43	4979.69	0.000
	4^{th} instar	3.92^{g}	7.54^{f}	11.16^{e}	14.76^{d}	18.37^{c}	21.91^{b}	25.56^{a}	0.14	54432	0.000
	Adult	3.60^{g}	6.80^{f}	10.00^{e}	13.20^{d}	16.41^{c}	19.60^{b}	22.80^{a}	0.24	14336	0.000

F, P, and LSD values on <0.05%

Mean, within a row, bearing different subscripts are significantly different

4 Conclusion

O. laevigatus was capable of preying on whitefly eggs, nymphal instars, and adults while completing its immature and mature developmental stages with *B. tabaci* nymphs and eggs as the only usable food. The duration, consumption, and fecundity of *O. laevigatus* were significantly influenced by feeding on different stages of *B. tabaci*.

Therefore, this study suggests that whitefly predators are favorable in the biocontrol of whitefly-infested vegetable crops.

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