Prey-Predator Interaction between *Orius albidipennis* (Hemiptera: Anthocoridae) and *Thrips tabaci* (Thysanoptera: Thripidae)

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Abstract: Thrips attacks different types of plants including buds, leaves and flowers where, heavy pest infestation can degrade the quality of the agricultural products that can reach the half. The study aimed to improve the understanding of prey-predator interaction between *Orius albidipennis* nymphs and *Thrips tabaci* nymphs and the degree of the response of the predator change when they feed on different prey densities. The predator *O. albidipennis* nymphs were collected from the colony reared in the biological control Res. Dep. ARC. Giza, Egypt, and starved for 4 h in glass vials containing small wet cotton with water without preys. *Thrips tabaci* nymph were introduced as prey into small Petri dishes at three densities (10, 20 and 30 nymphs), respectively. Starved predators were transferred to the experimental arena using smooth hair brush. The number of dead or live nymphs was counted. 25 replicates of each prey density were performed. The results showed that at densities of 10, 20, and 30 nymphs per arena, the consumed prey significantly increased with increasing prey density. When only 10 thrips nymphs were provided, *O. albidipennis* consumed a mean of 6.8±1.2 thrips nymphs per predator per day, even when 20 thrips nymphs were provided the consummation increased to 15.1±1.7 and increased to 26.5±2.9 when 30 thrips nymphs were provided, as a result, the obtained data indicates that the predators can efficiently find the thrips nymphs at low densities. However, the handling time (Th) of *O. albidipennis* which is sometimes consider as a good indicator of the predation rate that was the shortest at third nymphal instar than first nymphal instar when fed on nymphs of *T. tabaci*, respectively. The results demonstrated the calculation of the attack rate (à) and handling time (Th) significantly declined as stages reseed.

Keywords: Biological control, Predators, Predation ،Onion thrips, Pest management, Arthropods interaction

INTRODUCTION

In recent decades, the use of natural enemies played an important role through many biological control programs to reduce the impacts of pesticide residues, and pest resistance caused by insecticide, (Bale *et al.,* 2008). A wide variety of fruits, vegetables, flowers, and field crops are attacked by the Onion thrips. *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) is a significant pest. This species is highly polyphagous and has been reported in more than 300 species, with at least 25 families feeding on several cultivated crops (Khaliq *et al*., 2016). In particular, the Alliaceae family, such as onions and garlic, and in the Brassicaceae family, such as radish, cabbage and coliflower (Pourian *et al.,* 2009). It causes significant damage directly by feeding and indirectly through the transmission of tomato spotted wilt virus (TSWV). Its population can exceed 100 thrips / plant during the elevated infestation time (Ullah *et al*., 2010). Control of thrips is typically carried out by using of chemical applications, which may explain the widespread of pesticide resistance occurrence in onion thrips (Jensen, 2000). Due to its small size and cryptic habits, it is difficult to control this pest with insecticides (Richter *et al*., 1999). The species is well adapted to elevated temperatures (Safaei *et al*., 2015) and has no reproductive diapause caused by photoperiods and has strong foraging activity (Sobhy *et al*., 2010). *Orius* spp. (Heteroptera: Anthocoridae) can feed on various soft bodied arthropods, including aphids (Reitz *et al*., 2006). Among the genus, *Orius albidipennis* Reuter is a common predator in several regions of Iran (Hassanzadeh *et al*., 2015) and its ability as a potential biocontrol agent has been reported especially under greenhouse conditions (Rajabpour *et al*., 2011; Salehi *et al*., 2016). While some species of Orius are mass produced for augmentative biological control, growing concerns over the introduction of non-native species limits where any particular species may be deployed (van Lenteren *et al*., 2003; Louda *et al*., 2003). As a result, there is increased interest in other species of Orius that could be deployed as biological control agents in their native ranges. This interest is reinforced by the recognition that biological control agents also must be well acclimatized to environments where they would be deployed (Cocuzza *et al*., 1997). *Orius albidipennis*, a species of Orius of particular interest as a biological control agent, is commonly found in large numbers in various agricultural habitats throughout the Mediterranean basin, the Atlantic zone of Western Europe, and East Africa (Fritsche and Tamo, 2000). Also Chyzik and Ucko 2002 reported that *O. albidipennis* succeed to control thrips in pepper fields in Israel. In Egypt, *O. albidipennis* is very common throughout the country, south to Wadi Halfa, in the desert, and in cultivated areas, especially in corn and cotton fields. Functional response defines as the number of prey successfully attacked per predator as a function of prey density (Hamdan, 2006). It describes the way a predator responds to the changing density of its prey (Atlıhan, 2010). Many predators that have been released as bio control agents have shown to exhibit a type II response on their prey (Xiao and Fadamiro, 2010). Prey stage preference of some anthocorid bugs were studied by some authors. For example, prey stage preference of *Orius insidiosus* Say (Heteroptera: Anthocoridae) to different life stages of *Frankliniella occidentalis* Pergande (Thysanoptera: Thripidae) (Baez *et al*., 2004) and *Montandoniola confusa* Streito & Matocq (Heteroptera: Anthocoridae) to different life

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stages of *Gynaikothrips ficorum* Marchal (Thysanoptera: Phlaeothripidae) (Tavares *et al*., 2013) were previously investigated. In all of the studies, the predatory bugs showed obvious prey preference to some life stages of their prey. The aim of this study was to define the interaction of *O. albidipennis* nymph to different nymph densities of *Thrips tabaci* adults under laboratory conditions in order to improve the understanding of prey-predator interaction and How does the response of the predator change when they feed on different prey densities and their potential for suppressing pest populations in biological control programs.

MATERIALS AND METHODS

Thrips colony

The onion thrips, *Thrips tabaci* specimens were collected from the infested onion plants, (*Allium cepa* L.) planted in Shibin El Qanater city - Qalyubia Governorate - Egypt. Specimens were sent to insect classification unite in the Plant Protection Institute to be carefully identified. Screening potted plant was used to rear the thrips colony. Following the method reported by Madadi *et al*. (2006), the Onion thrips, *T. tabaci*, was reared on bean plants (*Phaseolus vulgaris* L. cv. Montano) under laboratory condition of 25ºC, 60% RH, 16:8h L:D. Three weeks after planting when the two first leaves appeared, the petioles were cut and leaves subsequently placed in the small vials (approx. 20 ml) filled with water. Bean leaves containing thrips eggs were put in similar containers until hatching.

Rearing of *Orius albidipennis*

The colony of *O. albidipennis* was established from the biological control Res. Dep. ARC, Giza, Egypt. Adults and nymphs were maintained in plastic jars, which were covered with muslin that was held in place by rubber bands. Each jar was provided with enough quantities of *T. tabaci*, a piece of cotton that had been soaked in a 10% honey solution and bean pods (*Phaseolus vulgaris* L.) as an oviposition substrate. Bean pods with newly laid eggs were removed and replaced daily. Jars were checked daily for hatching, after hatching nymphs were provided with *T. tabaci* and small balls of foam to reduce cannibalism. Colonies were maintained at 26±1°C and 60±10% RH.

Experimental procedure

The predator *O. albidipennis* nymphs were collected from the colony reared in the biological control Res. Dep. ARC. Giza, Egypt, and starved for 4 h in glass vials (7 cm × 2 cm) containing small wet cotton with water without preys. *Thrips tabaci* were introduced as prey into small Petri dishes at three densities (10, 20 and 30) nymph, respectively. Starved predators were transferred to the experimental arena using smooth hair brush. The number of dead or live thrips nymphs was counted. 25 replicates of each prey density were performed. Control with no predator as also replicated 25 times for each prey density to consider the natural mortality of the prey. They assessed with a Stereomicroscope.

The functional response of predators to different prey densities was expressed by fitting the data to Holling's equation (Holling, 1959)

$$Na= áTN/ (1+aThN)$$

Where: *Na* defines the number of prey attacked by a predator per time unit, *á* is search rate of a predator, *T* is the total time of exposure (1day in this experiment), *N* is the original number of prey items offered to each predator at the beginning of the experiment, and *Th* is handling time for each prey caught (proportion of the exposure time that a predator spends in identifying, pursuing, killing, consuming prey. Search rate, handling time and their standard errors were estimated from linear regression of disc equation. The relationship between the mean number of consumed preys versus original number of prey offered to each predator at the beginning of the experiment (prey consumed)/(prey density x 100) for all larval instars were estimated.

Data analysis

An independent t-test was used to evaluate differences in the number of thrips adults consumed by *O. albidipennis* at each nymph density. Data expressed in descriptive table as Mean±SD using SPSS v 23.0 statistical software. Data subjected to analysis of variance (Two ways ANOVA) through applying holme-sidak method using sigma plot V12.4 statistical software.

RESULTS AND DISCUSSION

The prey consumption by nymph of *O. albidipennis* in different combinations increased curvilinearly with prey density in all the three combinations were calculated and presented in Table (1).

The data analysis includes the mean ± SD for all Nymphal instars in different prey density. From the results, despite different prey density, starting with the record of the highest predation rate at the first nymphal instar, then followed by a decrease in the rate of predation until the third nymphal instar, followed by an increase in predation rate at fourth nymphal instar, and finally decrease in predation rate for fifth nymphal instar except for the 30 prey density group showing slightly increase in predation rate.

However, there are trends in our data suggest that the rate of prey consumption by a predator rises as prey density increases, but eventually levels off at an asymptote at which the rate of consumption remains constant regardless of increases in prey density. The results showed that at densities of 10, 20, and 30 nymphs per arena, the consumed prey significantly increased with increasing prey density. Extensive results carried out show that *O. albidipennis* was able to prey *T. tabaci*, and its predation showed a decelerating to increasing *T. tabaci* nymph number. When only 10 thrips were provided, *O. albidipennis* consumed a mean of 6.8±1.2 thrips nymphs per predator per day, even when 20 thrips nymphs were

provided the consummation increased to 15.1±1.7 and increased to 26.5±2.9 when 30 thrips nymphs were provided, which indicates that the predators can efficiently find the thrips nymphs at low densities (Fig. 1).

The difference in the mean values among the different levels of prey density is greater than would be expected by chance after allowing for effects of differences in nymphal instar. Results provides a good fit to the data when 30 vs.10 prey density ($p < 0.001$), 30 vs. 20 prey density ($p < 0.001$), 20 vs. 10 prey density ($p < 0.001$). There is a statistically significant difference ($P < 0.001$). Statistical analysis highlights that within 10 prey density group there was no significant differences ($P > 0.05$) in predation rate between different nymphal instar except between the first and third nymphal instar groups ($p<0.035$) ($P> 0.05$) respectively. Instead of 20 and 30 prey, density group there was no significant differences ($P> 0.05$) in predation rate between different nymphal instars. Another promising finding was that, the prey density played important role in predation rate showing significant differences ($P< 0.05$) between different density groups for different nymphal instar ($t= 4.554$, $p<0.001$ - $t= 3.669$, $p<0.001$- $t= 0.885$, $p= 0.377$), ($t= 6.421$, $p<0.001$ - $t= 3.325$, $p= 0.002$- $t= 3.096$, $p= 0.002$), ($t= 6.574$, $p<0.001$- $t= 3.456$, $p= 0.001$- $t=3.118$, $p=0.002$), ($t=5.471$, $p<0.001$- $t=3.309$, $p=0.002$ - $t=2.162$, $p=0.032$) and ($t=6.656$, $p<0.001$- $t=3.478$, $p=0.001$- $t=3.178$, $p=0.002$) were recorded for first, second, third, fourth and fifth nymphal instar respectively.

Table (1): Descriptive statistics for the predation for different prey density groups at different age groups

Treatments	Desc. Stat.	First nymphal instar	Second nymphal instar	Third nymphal instar	Fourth nymphal instar	Fifth nymphal instar
10 prey group	**Mean ± SE**	7.3±0.1	6.5±0.4	6.3±0.3	6.9±0.3	6.5±0.2
	SD	0.7	1.3	1.07	1.18	0.9
	Mini.	6.00	4.00	4.00	4.30	5.00
	Max.	8.50	8.50	8.00	9.30	8.70
20 prey group	**Mean ± SE**	15.3±0.3	15.2±0.3	15.08±0.3	15.3±0.5	15.2±0.5
	SD	1.19	1.40	1.5	2.1	2.2
	Mini.	13.50	11.70	11.00	10.00	11.70
	Max.	17.50	18.00	17.30	19.70	19.50
30 prey group	**Mean ± SE**	26.7±0.4	26.2±1.2	25.7±0.4	26.3±1.0	26.4±0.2
	SD	1.4	3.3	1.6	3.5	0.83
	Min.	24.0	17.70	23.00	22.00	24.70
	Max.	29.0	30.0	28.50	30.00	28.00

Prey-predators interaction

At higher prey density, the predator search rate (per predator per day) declined, showing that *O. albidipennis* needed to spend less time searching for prey at higher prey densities (Fig. 2). The number of prey nymph consumed by the fifth nymph instars of predator increased significantly as predator development. The percentage of prey consumed of each nymphal instar was negatively correlated with the offered prey densities. Obtained results were fitted to second degree of polynomial.

Estimated functional response parameters, when the *O. albidipennis* preys on *T. tabaci* nymph, are shown in Table (2). The handling time (Th) of *O. albidipennis*, which is sometimes a good indicator of the predation rate, was the shortest at third nymphal instar than first nymphal instar when fed on adults of *T. tabaci*, respectively. Obtained results were fitted to second degree of polynomial with R2 value of 0.99 for the 2nd, 3rd, 4th, 5th and 0.98 for the 1st nymphal instar.

The greatest theoretical maximum predation rate (1/Th) was estimated for the 3rd nymphal instar reaching 86.96 adult/day followed by the 4th and 5th nymphal instars being 74.07 and 48.78 eggs/day, respectively.

The results demonstrated the calculation of the attack rate (à) and handling time (Th) significantly declined as stages reseed. Those values have been associated with the changes on the prey and predator through their developmental stage. It has revealed generally increasing in the attack rate and decreasing in handling time with developing predator when fed on a particular stage of the prey.

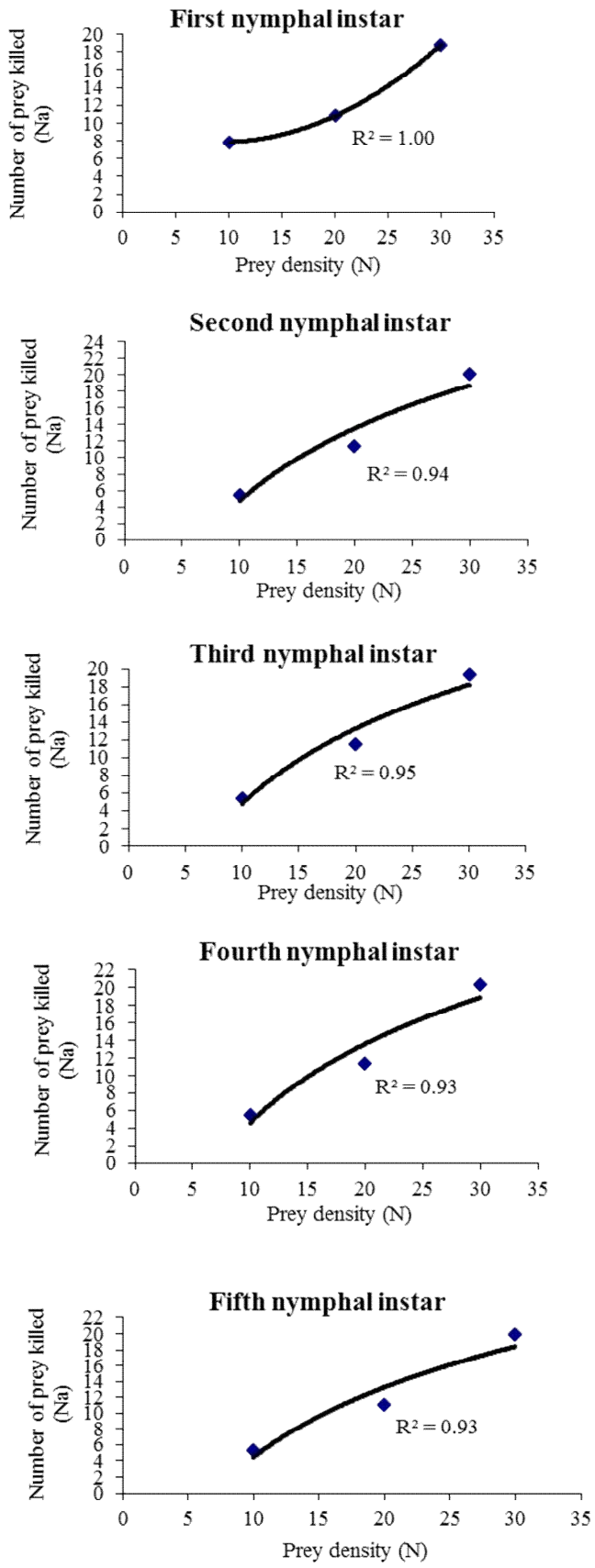

Fig (1): Relationship between search rate of *Orius albidipennis* nymph and density of *Thrips tabaci* nymph under laboratory condition

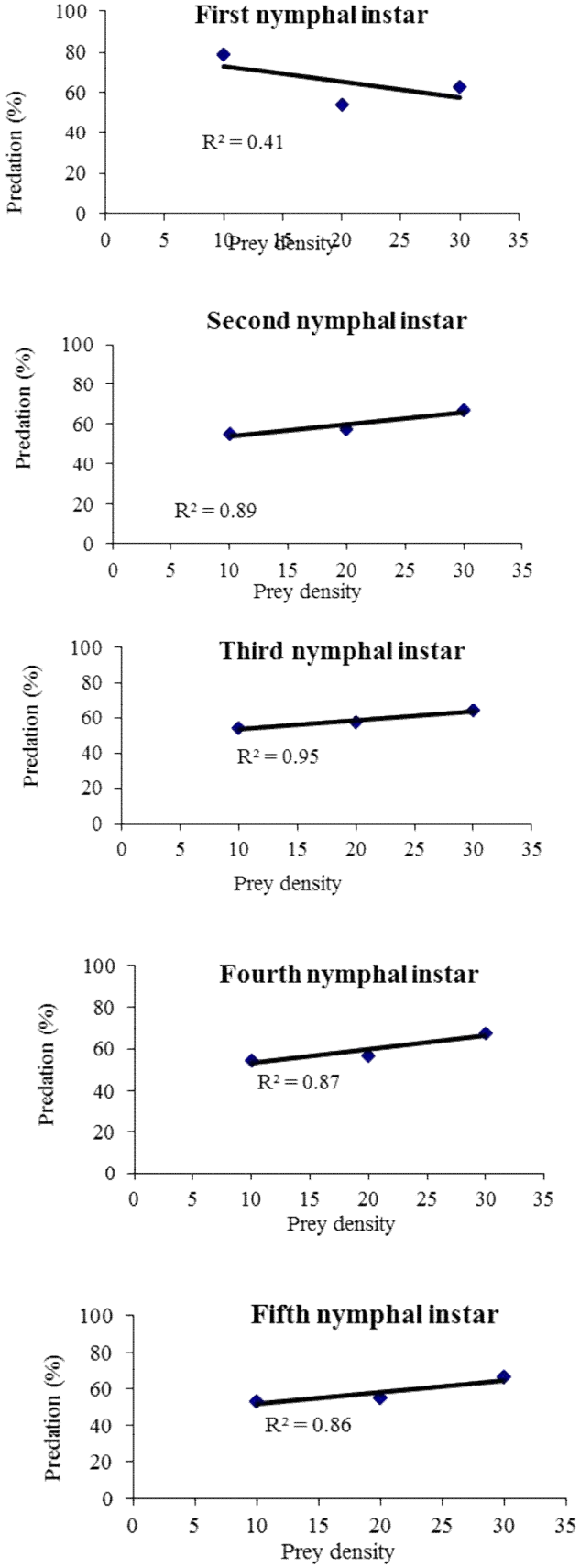

Fig (2): Predation capacity of *Orius albidipennis* nymph and density of *Thrips tabaci* nymph under laboratory condition

Table (2): The rate of successful search (á), handling time (T_h), and the maximum predation rate ($1/T_h$) describing type II functional response parameters of *Orius albidipennis* at different densities of *Thrips tabaci* Nymph

Nymphal instar	*á*	T_h	$1/T_h$	R^2
1st	0.377	0.048	20.88	0.98*
2nd	0.465	0.026	39.06	0.99*
3rd	0.513	0.012	86.96	0.99*
4th	0.510	0.014	74.07	0.99*
5th	0.468	0.021	48.78	0.99*

*significant at 0.05

Mendes *et al*. (2002) found that high prey consumption by orius may occur to fill a nutritional gap caused by low quality prey. In contrast, a relatively small amount of *E. kuehniella* eggs, a nutritionally high quality prey type, is sufficient to successfully mass rearing of *Orius* species (Yano *et al*., 2002; Mendes *et al*., 2002). However, other factors such as prey mobility, or prey defense tactics are important factors to consider in prey selection and attack by a predator (Eubanks and Denno, 2000). Biological control plays an important role in thrips management using *Orius*, since chemical treatments are not always able to keep thrips populations under the economic threshold. In fact, *Orius* proved an effective biological control agent with prey/predator ratios = 50, as reported in prediction models (Sabelis and van Rijn, 1997), and consistent with both laboratory and pepper field experiments with *O. Insidiosus* preying on *F. occidentalis* (Xu *et al*., 2006; Funderburk *et al*., 2000).

Many predators that have been successfully used as biocontrol agents for important pests in greenhouses exhibit a type II response to their prey (Pervez and Omkar, 2005; Xiao and Fadamiro, 2010). The results clearly indicate that the functional responses of *O. albidipennis* to different densities for different nymphal instars of *Thrips tabaci* are of type II. There is no study on the functional response of *O. vicinus* in the literature to the best of our knowledge. Marta *et al*. (2000) reported that *O. laevigatus* exhibits Type II responses when fed nymphs of *T. vaporariorum* and *F. occidentalis*. In the literature, there are many studies on different species of *Orius* preying on greenhouse pests, which report type II functional responses. For instance, *O. Niger* and *Orius minutus* (L.) exhibit type II functional responses when fed adults of *T. urticae* and 2nd instar individuals of the onion thrips (Fathi and Nouri-Ganbalani, 2010), *Orius albidipennis* (Reuter) fed eggs and 3rd instar nymphs of *B. tabaci* (Shahpouri *et al*., 2019), *Orius sauteri* (Poppius) fed adults of *Megalurothrips usitatus* (Bagnall) Thysanoptera: Thripidae) (Liu *et al*., 2018), *O. albidipennis* fed adults of *Megalurothrips sjostedji* Trybom (Thysanoptera: Thripidae) (Gitonga *et al.*, 2002) and *Orius tristicolor* (White) fed eggs of *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) (Queiroz *et al*., 2015). In contrast, *O. albidipennis* and *Orius strigicollis* (Poppius) fed eggs of *T. urticae* (Jalalizand *et al*., 2012; Banihashemi *et al*., 2017).

Functional response studies reported that the numbers of second instar and adult of *M. sjostedti* killed by *O. albidipennis* adults increased with an increase in pray density and temperature. Similar observations were obtained by (Kohno and Kashio 1998) and for *O. sauteri* (Poppius) and *Sericothrips variabilis* (Beach), respectively. Thrips have the ability to move their abdomen and emitting a drop of fluid (Lewis, 1997). This is likely to be the reason for the higher attack rates against the larvae and higher handling time for the adult thrips.

CONCLUSIONS

In conclusion, the present study has improved our understanding of the *T. tabaci* - *O. albidipennis* interaction in the laboratory. The results presented in these studies suggest that *O. albidipennis* could be considered for augmentative biological control of thrips in onion fields and they may have some value as a first step in estimating predatory capacity, but recommend that additional studies be conducted in a more field environment. In addition, this experiment done in the laboratory in small arenas that is very different from field conditions. Thus, further studies regarding the biological parameters and behavioral responses of these predators when attacking these preys are needed in order to clearly understand their potential capacity in terms of biological control.

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تفاعل الفريسة والمفترس بين تربس البصل *Thrips tabaci* (Thysanoptera: Thripidae) ومفترس الأوريس *Orius albidipennis* (Hetetroptera: Anthocoridae)

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يهاجم التربس أنواعًا مختلفة من النباتات والبراعم والأوراق والأزهار لنباتات المحاصيل. يمكن أن تؤدي الإصابة الشديدة إلى تدهور جودة المنتجات الزراعية التي يمكن أن تصل إلى النصف. هدفت الدراسة إلى تحسين فهم التفاعل بين الفريسة والمفترس بين حورية *Orius albidipennis* و *Thrips tabaci* واستجابة تغير المفترس عندما يتغذى على كثافات فريسة مختلفة. تم جمع المفترس *O. albidipennis* من المستعمرة التي تمت تربيتها في قسم المكافحة البيولوجية - الجيزة، مصر، وتم تجويعه لمدة ٤ ساعات في برطمانات زجاجية تحتوي على قطن صغير مبلل بالماء بدون فرائس. تم إدخال حورية *Thrips tabaci* كفريسة في أطباق بتري صغيرة بثلاث كثافة (١٠ ، ٢٠ و ٣٠)، على التوالي. تم نقل المفترس إلى التجربة باستخدام فرشاة شعر ناعمة. تم حساب عدد التريبس الحي أو الميت. تم عمل ٢٥ مكرر لكل كثافة فريسة. أظهرت النتائج أنه عند كثافة ١٠ و ٢٠ و ٣٠ بالغًا في كل تجربة، زادت الفريسة المستهلكة بشكل كبير مع زيادة كثافة الفريسة. عندما تم توفير ١٠ تريبس فقط، استهلك *O. albidipennis* متوسط ٦.٨ ± ١.٢ تريبس لكل مفترس في اليوم، حتى عندما تم توفير ٢٠ تريبس زاد الاستهلاك إلى ١٥.١ ± ١.٧ وزاد إلى ٢٦.٥ ± ٢.٩ عندما تم توفير ٣٠ تريبس، مما يشير يمكن المفترس العثور بكفاءة على التربس بكثافات منخفضة. وقت المناولة (Th) من *O. albidipennis* والذي يعد أحيانًا مؤشرًا جيدًا لمعدل الافتراس، كان الأقصر في المرحلة الحورية الثالثة من العمر الحوري الأول عند تغذيته على حوريات *T. tabaci* على التوالي. أظهرت النتائج أن حساب معدل الهجوم (à) ووقت المناولة (Th) انخفض بشكل ملحوظ مع إعادة ملء المراحل. ارتبطت هذه القيم بالتغييرات التي طرأت على الفريسة والحيوانات المفترسة خلال مرحلتها التنموية.

الكلمات المفتاحية: المكافحة البيولوجية، تربيس البصل، الافتراس، إدارة الآفات