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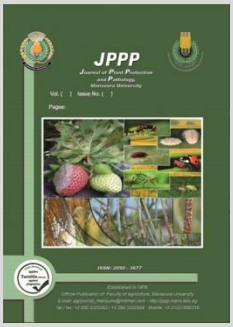
Ecological and Biological Studies on the Mirid Zoophytophagous Bug *Nesidiocoris tenuis* Reuter as a Predator of the Tomato Leaf Miner *Tuta absoluta*

Awadalla, S. S.[1*]; M. H. Bayoumy[1]; Ekram A. Abdou[2]; M. F. Olyme[2] and Nesreen E. EL-Mowafy[2]

[1]Economic Entomology Department, Faculty of Agricultural, Mansoura University.
[2]Plant Protection Research Institute, Sakha Agriculture Research Center, Kafr El- Sheikh.



ABSTRACT

Tuta absoluta is a serious pest infesting tomato with 80-100% losses. *Nesidiocoris tenuis* is a zoophytophagous species that feed on both tomato plants and *T. absoluta*. Effect of plantation dates on both species during 2020 and 2021 seasons was examined. Further, effect of food types on biological aspects of *N. tenuis* was investigated. In February plantation, the highest density of *N. tenuis* was recorded on the fourth-week of May of both seasons, while the highest density for *T. absoluta* was on the fourth- and second-weeks of April and May during the first and second seasons, respectively. In June plantation, the highest densities of *N. tenuis* and *T. absoluta* were on the fourth-weeks of September and August during both seasons, respectively. In September plantation, the highest density of *N. tenuis* was on the second- and third-weeks of October during the first and second seasons, respectively, while the highest density for *T. absoluta* was on the first-week of January during both seasons. The numbers of *N. tenuis* positively coincided with those of *T. absoluta* during February and June plantations. No significant difference in egg period between females that fed on tomato plants or infested tomato plants with *T. absoluta* was detected. The nymphal stage duration of *N. tenuis* was shorter when fed on infested tomato plants with *T. absoluta* than on tomato plants or *T. absoluta* larvae. The adult fed with the infested tomato plants with *T. absoluta* lived and produced more eggs than those fed tomato plants or *T. absoluta* larvae.

Keywords: Development, Density, Fecundity, Longevity, Zoophytophagous

INTRODUCTION

The tomato bug, *Nesidiocoris tenuis* Reuter (Hemiptera: Miridae) is one of the mirid bugs with zoophytophagous behavior that can feed on both plants and insect preys (El Dessouki *et al.*, 1976). It is used to control various lepidopteron insect pests that attacking tomato plants such as the tomato leaf miner *T. absoluta* (Arno *et al.*, 2009; Molla *et al.*, 2011; El-Arnauty *et al.*, 2012; Biondi *et al.*, 2016). In the open field and greenhouses, the population of *N. tenuis* found to be high depending on environmental factors like temperature, plantation dates and what it feed (Sanchez *et al.*, 2009; Awadalla *et al.*, 2019 a and b). Further, *N. tenuis* found to be in high population in the end of February and in June plantations, causing damages to tomato plants as necrotic ring and deposit the eggs on both leaves and flower petioles, and whitish halos on fruit (Awadalla, 1980; Urbaneja *et al.*, 2005; Arno *et al.*, 2006). On life cycle, the duration times of different stages were affected by the host plants and/or prey species (Arno *et al.*, 2010; Molla *et al.*, 2014). The egg deposited on the newly green leaves singly and takes from 6 to 7 days to give the first newly yellow green nymphs (Kim *et al.*, 2016). The female laid the eggs on plants that hatched to nymphal stages which have the ability to develop with feeding on plant juice as a source of water and supplementary nutrients (Biondi *et al.*, 2016; Puysseleyr *et al.*, 2013). Therefore, the present experiments aim to 1) study the influence of plantation dates on populations of *T. absoluta* and its prey *N. tenuis*, 2) to examine the effect of food type on some biological aspects of *N. tenuis*

MATERIALS AND METHODS

1.Field experiments

The present experiments were conducted to study the population density of the tomato leaf miner, *T. absoluta* and its predatory insects in a farm located in Kafr El-Sheikh governorate. To study influence of plantation dates (February, June and September) on populations of the tomato leaf miner *N. tenuis* and *T. absoluta*, Field study was conducted in an experimental area about 1000 m^2. Seeds of tomato plants were sown in greenhouse before transferring to the field, since seedlings were 25-30 days old. These seedlings were sown in end of February, first of June and end of September. The normal agricultural practices, of land preparation, irrigation, and mechanical weeds control, were followed as recommended, whereas chemical control was neglected during both growing seasons.

Sampling started one week after transplantation in field by using direct count method in which visual direct counting of *T. absoluta* larvae on the whole plant was recorded. Every week, 100 randomly tomato plants were visually inspected to record the number of *T. absoluta* larvae during the two growing seasons (2020 and 2021). The insect predators were also recorded directly on the same plants. The adults and immature stages of predators were weekly recorded on 100 plants before the sunset (6 PM) when these stages are more stable on the plants.

2. Biological experiments

The nymphal stage of *N. tenuis* was collected and transferred from tomato field located in Kafr El Sheikh

* **Corresponding author.**
E-mail address: awadalla28@yahoo.com
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region to the laboratory of biological control, Department of Plant Protection, Sakha branch. The nymphal stage was reared on tomato plant until reaching their adult stage. Adults (one week old) were inputted in cages with tomato plants of 30-35 days old to oviposit (5 male: 5 female/cage). The first yellow green nymphal stage was collected and counted to be used in all laboratory studies. The laboratory conditions were conducted at 28±2ºC, 60 ±10% RH and photoperiod of 12:12h (L: D) for all studies depending on recommendations given by Gwennan *et al.* (2009) who reported that 28 ºC is the suitable temperature to rear the tomato bug *N. tenuis*. Three food types (tomato plants, *T. absoluta* larvae, and tomato plants infested with *T. absoluta* larva) were used to rear the tomato bug, *N. tenuis*. Ten individuals of the yellow green nymphal stage were transferred to a cage with tomato plants. Each cage containing one plant (30-35 days old) that covered by plastic tube with 30 cm tall and tided with part of clothes by rubber band. Other ten yellow green nymphs were transferred to new cage containing parts of tomato plants and the first and second instars of the tomato leaf miner *T. absoluta*. Ten replicates were applied for each of both treatments. The development of the five nymphal stages were distinguished using morphological characters and morphological information according to Kimi *et al.* (2016). In respect to rearing the tomato bugs on *T. absoluta* larvae, as a prey, glass tube with a diameter of 5.0 cm covered with piece of cloth and tied with a rubber band use as prey cages. Larvae of *T. absoluta* were collected from open field and provided for the tomato predatory bug as prey with a prey-predator supposed by Lakshmi *et al.* (2018). Ten individuals of the first yellow green nymphal stage of *N. tenuis* transferred to one tube containing *T. absoluta* larvae. Each glass cage contained a small tube containing wetted cotton piece. Prey larvae were provided daily until predator nymphs reached their adult stage. Ten replicates were used. Nymphal instars were observed daily until completed their development. The new cages of adults were changed every three days for five times to reduce the damages on tomato plants and also to decrease self-feed. The egg duration was recorded when first newly nymphs appeared. The produced yellow green nymphs in all cages counted to have the total fecundity of females. Adult's longevity was also estimated. There was a difficulty in treating with counting the numbers of egg deposited on tomato leaves so that we stepped the preoviposition period by 2.5 days according to (Puysseleyr *et al.*, 2013).

3. Statistical analysis

Data of developmental times, preadult survival rates, longevity and female's fecundity were analyzed by one-way ANOVA followed by Duncan's multiple range test to separate means if F was significant.

RESULTS AND DISCUSSION

Results

1. Effect of planting dates on population of *N. tenuis* and *T. absoluta*

The results arranged in Figure (1) show the population density of the tomato bug *N. tenius* and the tomato leaf miner *T. absoluta* in February plantation during season 2020. The highest density (160 individuals/plant) of *N. tenuis* was recorded in the fourth week of May, whereas the highest density (56 larvae/plant) of *T. absoluta* was recorded in the fourth week of April. In May, the number of *T. absoluta* larvae was decreased as a result of increasing the number of its predator, *N. tenuis*.

In February plantation of 2021 season, the highest density (133 individuals/plant) of *N. tenuis* was recorded in the fourth week of May, whereas the highest density (65 larvae/plant) of *T. absoluta* was recorded in the second week of May. Also, number of *T. absoluta* larvae was decreased due to increase the number of its predator, *N. tenuis* in May (Fig. 2).

The results arranged in Figure (3) show the population density of the tomato bug *N. tenius* and the tomato leaf miner *T. absoluta* in June plantation during season 2020. The highest density (680 individuals/plant) of *N. tenuis* was recorded in the fourth week of September, whereas the highest density (24 larvae/plant) of *T. absoluta* was recorded in the fourth week of August. In September, the number of *T. absoluta* larvae was decreased as a result of increasing the number of its predator, *N. tenuis*.

In June plantation of 2021 season, the highest density (450 individuals/plant) of *N. tenuis* was recorded in the fourth week of September, whereas the highest density (130 larvae/plant) of *T. absoluta* was recorded in the second week of August. Also, number of *T. absoluta* larvae was decreased due to increase the number of its predator, *N. tenuis* in September (Fig. 4).

The results arranged in Figure (5) show the population density of the tomato bug *N. tenius* and the tomato leaf miner *T. absoluta* in September plantation during season 2020. The highest density (5 individuals/plant) of *N. tenuis* was recorded in the second week of October, whereas the highest density (20 larvae/plant) of *T. absoluta* was recorded in the end of November.

In September plantation of 2021 season, the highest density (8 individuals/plant) of *N. tenuis* was recorded in the third week of October, whereas the highest density (22 larvae/plant) of *T. absoluta* was recorded in the first week of January. The population of *N. tenuis* found to be disappeared in the end of November (Fig. 6).

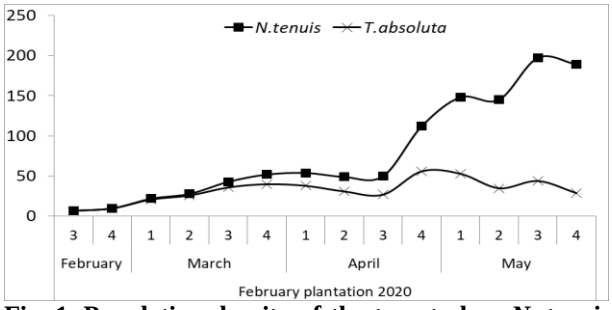

Fig. 1. Population density of the tomato bug *N. tenuis* and the tomato leaf miner *T. absoluta* in February plantation during 2020 season at Kafr El Sheikh region.

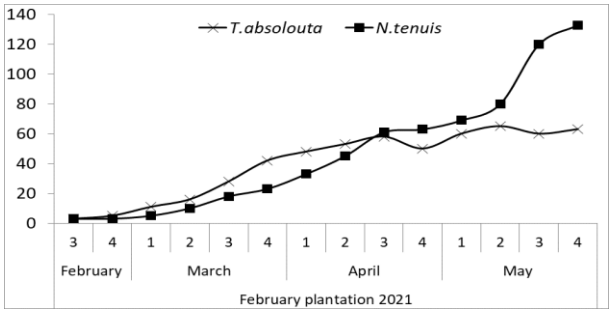

Fig. 2. Population density of the tomato bug *N. tenuis* and the tomato leaf miner *T. absoluta* in February plantation during 2021 season at Kafr El Sheikh region.

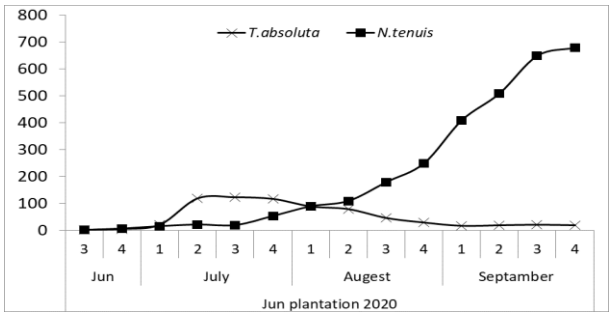

Fig. 3. Population density of the tomato bug *N. tenuis* and the tomato leaf miner *T. absoluta* in June plantation during 2020 season at Kafr El Sheikh region.

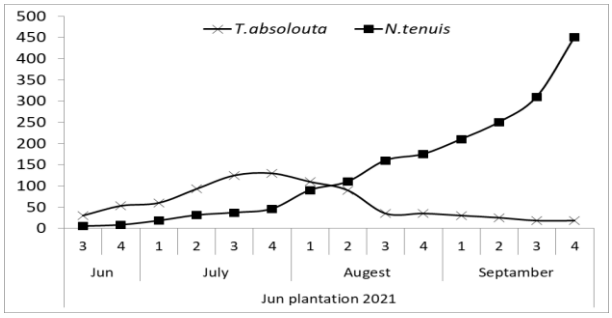

Fig. 4. Population density of the tomato bug *N. tenuis* and the tomato leaf miner *T. absoluta* in June plantation during 2020 season at Kafr El Sheikh region.

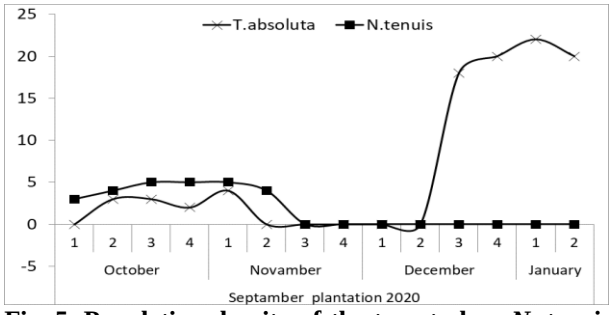

Fig. 5. Population density of the tomato bug *N. tenuis* and the tomato leaf miner *T. absoluta* in September plantation during 2020 season at Kafr El Sheikh region.

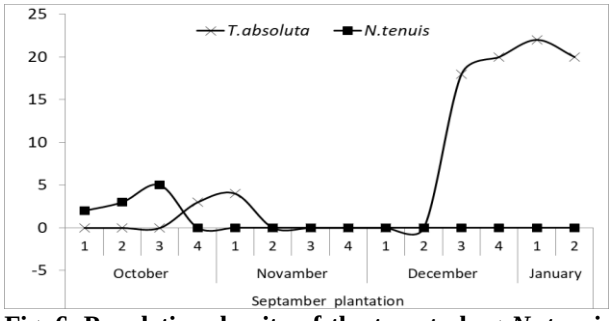

Fig. 6. Population density of the tomato bug *N. tenuis* and the tomato leaf miner *T. absoluta* in September plantation during 2021 season at Kafr El Sheikh region.

Data arranged in Table (1) show the average numbers of the tomato leaf miner, *T. absoluta* and the tomato bug, *N. tenuis* in the three different planting dates during the two seasons (2020 and 2021). The highest average number of *T. absoluta* was estimated in June plantation of the first and second seasons (51.4 ± 12.0 and 60.8 ± 10.9, respectively). In addition, the highest average number of *N. tenuis* was estimated in June plantation of both seasons (285.9 ± 96.1 and 263.4 ± 88.1, respectively). The lowest average number of *T. absoluta* was in September plantation of the first and second seasons (7.9 ± 3.1 and 6.2 ± 2.4, respectively). In addition, the lowest average number of *N. tenuis* was in February plantation of both seasons (1.4 ± 0.6 and 2.5 ± 0.4, respectively).

The simple correlation coefficient between numbers of *T. absoluta* and those of *N. tenuis* in tomato plants the three different plantation dates of 2020 and 2021 seasons is given in Table (2). The numbers of *N. tenuis* positively coincided with those of *T. absoluta*, in a significant way, during February and June plantations, but not during September plantation.

Table 1. The average numbers (±SE) of the tomato leaf miner, *T. absoluta* and its predator *N. tenuis* in the three different tomato plantations during the two seasons (2020 and 2021) at Kafr El-sheikh region.

	Plantation date		
	February	**June**	**September**
T.absoluta 2020	32.3 ± 3.8	51.4 ± 12.0	7.9 ± 3.1
T.absoluta 2021	31.1 ± 4.8	60.8 ± 10.9	6.2 ± 2.4
N.tenuis 2020	1.4 ± 0.6	285.9 ± 96.1	2.8 ± 0.9
N.tenuis 2021	2.5 ± 0.4	263.4 ± 88.1	4.1 ± 0.7

Table 2. The simple correlation coefficient between numbers of *T. absoluta* and those of *N. tenuis* in different plantation dates during seasons 2020 and 2021.

year	Plantation date		
	February	**June**	**September**
2020	0.454*	0.443*	-0.425^{ns}
2021	0.838***	0.61**	-0.338^{ns}

*** Correlation is significant at the 0.05 level, ** Correlation is high significant at the 0.01 level, ***Correlation is highly significant at the 0.001 level, and ^{ns} Correlation is not significant**

The tomato bug *N. tenius* recorded the highest population in June plantation. The same finding is reported by Sanchez (2008), Hassan pour *et al.* (2015) and Awadalla *et al.* (2019a, b). The highest population starting to rise up from May to July with high numbers of necrotic rings which found to be similar to that reported by Perdikis *et al.* (2009) and Varshny and Ballal (2017). Also, the population found to be declined to disappearance during the end of October on tomato plants which is in consistent with results of Sanchez (2008).

2. Effect of food type on some biological studies of the tomato bug *N. tenuis*

Data given in Table (3) show the duration times of the immature stages of *N. tenuis* under three different feeding conditions. No differences found on egg stage that recorded (7.0 ± 0.49) and (6.4 ± 0.21), respectively. For nymphal stage, it found to be shorter by feeding on tomato plants infested with *T. absoluta* larvae and on *T. absoluta* larvae than feeding on tomato plants only. The duration time of nymphal stage of *N. tenuis* did not significantly differ between nymphs fed on tomato plants infested with *T. absoluta* and those fed on *T. absoluta* only. The total

duration was found to be shorter in case of feeding with *T. absoluta* than in feeding with other food types.

In case of feeding on tomato plant only, the longevity of *N. tenuis* adults was shorter than that when predator fed on the other two food types. The fecundity of *N. tenuis* female was higher when fed on tomato plants infested with *T. absoluta* larvae than on the other two food types.

Table 3. Effect of feeding type (tomato plants, tomato plants with *T. absoluta* larvae and larvae of *T. absoluta*) on immature stages, adult longevity and female fecundity of the tomato bug *N. tenius* under laboratory at conditions of 28±2ºC, 60 ±10% RH and photoperiod of 12:12h (L: D).

Stage	Feeding types		
	Tomato plants	Tomato plants + *T. absoluta* Larvae	Larvae of *T. absoluta*
Incubation period	7.0 ± 0.49 a	6.4± 0.21 a	7.0 ± 0.49 a
First nymphal instar	1.3 ± 0.33 a	1.0 ± 0.00 a	1.0 ± 0.00 a
Second nymphal instar	2.0 ± 0.00 a	1.0 ± 0.00 b	1.0 ± 0.00 b
Third nymphal instar	1.7 ± 0.33 a	1.3 ± 0.33 b	1.3 ± 0.33 b
Fourth nymphal instar	1.0 ± 0.33	1.0 ± 0.00 b	1.7 ± 0.00 a
Fifth nymphal instar	1.7 ± 0.33 a	1.7 ± 0.33 a	1.7 ± 0.33 a
Total nymphal stage	8.8 ± 0.33 a	6.0 ± 0.21 b	6.00 ± 0.21 b
Total development	15.8± 0.49 a	12.4± 0.33b	13.0 ± 0.33b
Adults longevity	18.8±0.95 a	21.4±0.25 b	20.2±0.35 b
No.egg / female	43.2±5.5 a	91.6±4.25 b	91.6±4.25 b

Means with the same letters in a row is not significantly different at 5% level

Absence of significant difference in egg incubation period between females fed on tomato plant and those fed on infested tomato plant with *T. absoluta* larvae is consistent with that reported by Gwennan *et al*. (2009), Sanchez *et al*. (2009) and Puysseleyr *et al*. (2013).

The duration time of *N. tenuis* nymphal stage found to be shorter in case of feeding on infested tomato plants with *T. absoluta* larvae than feeding on tomato plants or larvae of *T. absoluta*. These results are agreeing with those of Sanchez *et al.* (2009), Arno *et al*. (2010), Puysseleyr *et al.* (2013), Molla *et al*. (2014), and Awadalla *et al.* (2019 a, b).

The adults provided with infested tomato plants with *T. absoluta* lived more than those provided only either by tomato plants or larvae of *T. absoluta*. These results are in agreement with those of Puysseleyr *et al*. (2013), Molla *et al.* (2014), and Kim *et al.* (2016). The fecundity of females provided with infested tomato plants with *T. absoluta* was higher than those provided only either by tomato plants or larvae or *T. absoluta*. These results are in consistent with those of Gwennan et al. (2009), Sanchez *et al.* (2009), Puysseleyr *et al.* (2013) and Molla *et al*. (2014).

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دراسات ايكولوجية وبيولوجية علي حشرة بقة الطماطم ذات سلوك التغذية النباتي الحيواني كمفترس رئيسي لصانعة انفاق الطماطم

سمير صالح عوض الله[1]، محمد حسن بيومي [1]، اكرام عبده و[2] ، مصطفى فاروق عليمي[2] و نسرين الموافى[2]

[1]قسم الحشرات الاقتصاديه –كلية الزراعة جامعة المنصورة

[2]معهد بحوث وقاية النباتات –مركز البحوث الزراعية – الدقي –الجيزة

صانعة انفاق الطماطم تعد من أهم الآفات الحشرية التي تصيب الطماطم وتسبب خسائر تتراوح من 80 الى100%. كما تعد بقة الطماطم ذات سلوك التغذية النباتي الحيواني احد اهم المفترسات التي تهاجم صانعة انفاق الطماطم. تم فحص تاثير تواريخ الزراعة علي كلا النوعين الحشريين خلال موسمي 2020 و 2021، كما تم دراسة تاثير نوع الغذاء علي المقاييس البيولوجية لبقة الطماطم. اظهرت النتائج ان اعلي كثافة عددية لبقة الطماطم كانت في الاسبوع الرابع من مايو خلال كلا سنتي الدراسة، بينما اعلي كثافة لصانعة انفاق الطماطم كانت في الاسبوع الرابع والثاني من شهر ابريل ومايو خلال الموسم الاول والثاني علي التوالي. كانت اعلي كثافات عددية من كلا الحشرتين خلال عروة يونيه في الاسبوع الرابع من شهر سبتمبر واغسطس خلال الموسم الاول والثاني علي التوالي، اما في عروة سبتمبر فان اعلي كثافات عددية لبقة الطماطم كانت خلال الاسبوع الثالث من اكتوبر خلال كلا موسمي الدراسة، اما صانعة انفاق الطماطم سجلت اعلي كثافة عددية في الاسبوع الاول من يناير خلال كلا موسمي الدراسة. اظهرت النتائج ان اعداد بقة الطماطم كانت ترتبط ايجابيا باعداد صانعة انفاق الطماطم خلال عروات فبراير ويونيه. كما اظهرت النتائج انه لا توجد اختلافات معنوية في فترة حضانة البيض بين اناث بقة الطماطم التي تغذت علي نباتات الطماطم وتلك التي تغذت علي نباتات الطماطم المصابة بصانعة انفاق الطماطم. اما فترة الطور الحوري لبقة الطماطم كان اقصر عندما تغذت علي نباتات الطماطم المصابة بالحشرة، كذلك عاشت بقة الطماطم فترة اطول وانتجت بيض اكثر عندما تغذت علي نباتات الطماطم المصابة مقارنة بتلك التي غذيت علي نباتات الطماطم او يرقات صانعة انفاق الطماط فقط.