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Assessment of development and consumption rate of *Macrolophus caliginosus* Wagner predator on different prey stages

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Abstract

Background *Macrolophus caliginosus* Wagner is one of the most important polyphagous predatory mirid bug that attack many agriculture insect pests.

Methods The present study was carried out to show the effect of different prey stages as *Tuta absoluta* (eggs and fourth larval stage), *Bemisia tabaci* (eggs and three nymph stages) and *Aphids gossypii* (1st nymph stage) on the life cycle and consumption rate of male and females of *M. caliginosus* as predator under laboratory condition. The experiments were started by collecting the first stage of *M. caliginosus* nymph and placed separately on acalypha plants situated on saturated cotton pads inside Petri dishes with an excess of each prey.

Results The results showed that the developmental period of the total immature stages of *M. caliginosus* female are affected by type and stage of tested prey. So, the duration of larval stages of female was significantly recorded the longest in case of feeding on eggs of *T. absoluta* compare to 1st nymph of *A. gossypii*. In addition to extension the adult longevity of female *M. caliginosus,* which fed on the 1st nymphal instar of *B. tabaci* more than the other pests. The consumption rate of total immature stages and adult *M. caliginosus* female were fed on eggs of *B. tabaci* was more than the other test pests. While the consumption rate of total immature stages and adult of male *M. caliginosus* were fed on eggs of *B. tabaci* was higher than that of the other pests.

Conclusions The search was given the highlight focus on ability of mirid bugs to consume different insect species "stages" that might be facilitate rear predatory bugs under laboratory condition.

Keywords *Macrolophus caliginosus*, *Tuta absoluta*, *Bemisi tabaci*, *Aphis gossypii*, Longevity, Consumption

Background

Leaf bugs belong to the family Miridae, order Hemiptera are classified as omnivorous insects which had the ability to disperse, persist and colonize new habitats (Messelink et al. 2014; Salas et al. 2017). These types of bugs had a wide range of food sources, such as pollen, nectar or other plant material of cultivated and wild origin rather than insect pests. However, the benefits of controlling pest species may be counteracted by the economic damage they may cause as herbivores (Castañé, et al. 2011; Urbaneja et al. 2019; Pérez-Hedo et al. 2017).

Recently, the use of these insects in biological control programs against sucker insects and small larvae of Lepidoptera among other horticultural pests has increased and around 20 species are currently commercialized (van Lenteren et al. 2018).

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Macrolophus caliginosus Wagner is one of the most important polyphagous predatory mirid bugs, which attack many insect pests, especially whiteflies, aphids, and thrips which infested vegetable plants under greenhouses. In last decade, Integrated Pest Management (IPM) in tomato was focused on using mirid bugs in decreasing harmful insect population especially under green house and considered it promising predator (Albajes and Alomar 1999).

In Egypt, the tomato crop is considered one of the most economic export crop which was recorded as second of the most important tomato producers in the world (WPTC 2019). The most of tomato production is lost due to severe damages caused by destructive pests and diseases (Khalil 2013). Since the tomato is infected by many pests, including sap-sucking pests and Tomato leaf miner (TLM), *T. absoluta* caused a reduction in the quality and quantity of the crop product (Alston 2007; EPPO 2008, 2009; Desenex et al. 2011; FERA 2009; Sabbour 2014).

In Egypt, *T. absoluta* was recently considered a key insect pest on tomato plants, both in greenhouses and open-fields. Damage is caused by larval tunneling and they can penetrate young stems and fruits which finally result in the loss of over 80% of fruits (Desneux et al. 2011). The whitefly *Bemisia tabaci* and *Aphids gossypii* is a notorious devastating sap-sucking insect pest that causes substantial crop damage and yield losses. Globally they cause severe damage to the agriculture crops estimated to be at least $470 billion per annum (Gurr and You 2016).

The objectives of the present work are studied the role of different pests' stage of *T. absoluta*, *B. tabaci* and *A. gossypii* as preys on development of *M. caliginosus* under laboratory conditions. From the perusal of studies; it seen that this is the first report from Egypt on the suitability of various pest insect species as prey for the Egyptian strain of *M. caliginosus.*

Methods

Rearing of tested prey

The experiment was started by raring and maintained the tested preys under laboratory conditions as follows:

Tuta absoluta

A laboratory colony of *T. absoluta* was established from larvae and pupae collected from a tomato crop located at Berncht, Al-Ayat Giza province, Egypt. The laboratory colony was kept under controlled conditions: temperature (25 ± 0.5 °C), photoperiod (12 h L: 12 h D) and relative humidity (65 ± 5%) in a wooden entomological cage (50 × 30 × 30 cm^3) covered with fine mesh (Silva et al. 2011). The larvae were provided with fresh tomato leaves until pupate and adult emerged. The emerging adults were collected by aspirator to be placed in another glass cage (20 × 10 × 20 cm^3) which contain pots of fresh tomato plant). A piece of cotton saturated with sugar solution was placed inside the cage as a food source for adults. Daily, deposited eggs were collected and counted under a stereoscopic binocular microscope. A part of the eggs was placed on tomato leaflets to be subsequently used in experiments. The other eggs were put on fresh tomato leaves which were placed on wet cotton pieces at petri-dish (30 cm) to obtain newly hatched larvae (1st instar larvae). After hatching the larvae go through four instars, which completed in about 20 days, i.e., each instar spends 4–5 days to transfer to other one under laboratory condition (Attwa et al. 2015; El-Shafie 2020).

Bemisia tabaci and Aphis gossypii

A laboratory colony of *B. tabaci* and *A. gossypii* were established with immature stages which collected from leaves of tomato plants and were placed in a separate wooden cage containing pots of tomato plants. In the case of *B. tabaci* cage will continue until adults emerge and then female will deposited eggs in the fresh tomato plant. The next day the plants were taken out of cages and eggs placed on tomato leaflets to use in experiment, eggs are white when first laid, and become brown prior to hatching (eggs hatched in 5 days) to the first nymphal stage which is called crawlers. After 5 days it develops to the third nymphal instars which use in the experiment (Lutfi et al. 2019). On other cage containing Aphids culture, the 1st nymphal instar were collected to use in the test (Gavkare and Gupta 2013).

Predator rearing

Females and males of *M. caliginosus* were collected from field and placed individually inside plastic vials with soaked cotton plugs and covered with toll. One day later, cotton plugs were removed and then the adults placed inside a cage (30 × 50 × 30 cm^3) that contained tomato plants infested with various stages of *T. absoluta* (eggs and larvae) for two days. The female of *M. caliginosus* oviposit in the tissue of leaf, vein or stalk of tomato plants. For this reason, after 48 h plants cut into small parts and the pieces were placed on acalypha plants situated on saturated cotton pads inside Petri dishes (10 cm in Diameter) for 5–6 days until the first newly hatched nymphs emerged.

Influence of diets on the development, adult longevity and consumption rates of females and males of *M. caliginosus*

Leaf discs of Acalypha (*Acalypha hispida*) (3 cm) were put on a cotton pad (5 cm) soaked in distilled water in a petri-dish (10 cm), the margin of each disc was covered with water to force the insect to stay on the leaf disc. Water was added daily to the petri-dishes to maintain the cotton soaked.

A total of 30 newly nymphal instars of *M. caliginosus*/prey considered for each food item (*T. absoluta*, *B. tabaci,* and *A. gossypii*) were transferred singly to each leaf plants. Each 1st nymphal stage and subsequent life –stages were provided with surplus amounts of each food item in the following amounts: 30–35 eggs; 25–30 1st larval instars; 15–20 2nd larval instars; 10–15 3rd and 4th larval instars of *T. absoluta* 0.50–100 eggs*;* 20–40 1st nymphal; 10–30 4th nymphal of *B. tabaci*. 5–15 1st nymphal instar of *A. gossypii* (more than that consumed daily). Food was replenished every other day. Developmental times and consumption rates were observed every 12 h. Observation was extended also for females or males till all individuals died.

Statistical analysis

Data on the developmental period and consumption rates of the females and males per each prey and then per all prey were analyzed by one-way ANOVA (Howell 2008). The means were compared by Tukey HSD at a 5% probability level.

Results

Influence of different prey stages on the development and consumption rates of the females and males of *M. caliginosus.*

The developmental period of the total immature stages of *M. caliginosus* female was significantly the longest (28.2 ± 0.1 day) when fed on eggs of *T. absoluta* compared to its' feeding on its'3rd larval stage (18.46 ± 0.1 day) or/and to 1st nymph of *A. gossypii* was 20.1 ± 0.3 days (Table 1).

While the adult longevity of female *M. caliginosus* was significantly the longest (24.0 ± 0.3 day) when fed on 1st nymphal instar of *B. tabaci* compared to its' 3rd instar was 19.5 ± 0.3 day or/and 1st nymph of *A. gossypii* was 19.2 ± 0.6 days.

On the other hand, the consumption rates of their nymph stage were significantly recorded as the highest when feeding on eggs of *B. tabaci*. (564 ± 0.1 prey/day) compared to 1st aphid nymph was 43.2 ± 0.1 prey/day (Table 2). In addition of the highest consumption rate to prey from adult females was recorded on eggs of *B. tabaci* (715 ± 3.9 prey/day) compared to 1st aphid nymph was 61.3 ± 1.6 prey/day. The lowest consumption rate to nymph stages and adults was recorded on the 3rd or 4th larvae of *T. absoluta* (20.07 ± 0.3 and 38.3 ± 1.3 prey/day).

Table 1 Mean developmental period of *Macrolophus caliginosus* female fed on various stages of *Tuta absoluta*, *Bemisia tabaci* and *Aphis gossypii*

Prey	Developmental stages						
	1st Nymphal instar	2nd Nymphal instar	3rd Nymphal instar	4th Nymphal instar	5th Nymphal instar	Developmental period of total immature	Adult longevity
Tuta absoluta							
Egg	3.3 ± 0.12 bD	3.8 ± 0.14 aC	3.7 ± 0.11 aE	3.7 ± 0.11 aE	4.8 ± 0.17 cC	28.2 ± 0.1 aC	22.2 ± 0.4 bD
1st Larvae	2.5 ± 0.13 bD	3.0 ± 0.00 aC	2.4 ± 0.13 bE	2.7 ± 0.13 bE	2.5 ± 0.13 bA	21.06 ± 0.1 bC	17.7 ± 0.2bD
2nd Larvae	3.5 ± 0.13 aC	3.5 ± 0.13 aD	4.07 ± 0.16 cE	4.07 ± 0.16 cC	4.2 ± 0.16 cC	27.28 ± 0.1 aE	20.0 ± 0.4 cE
3rd and 4th Larvae	3.4 ± 0.14 aC	2.3 ± 0.13 bE	3.2 ± 0.12 aD	3.2 ± 0.12 aE	3.0 ± 0.4 aC	18.46 ± 0.1 cB	14.6 ± 0.18 dF
ANOVA	$F = 12.5$ $P = 0.00$ $df_{3.56}$	$F = 30.4$ $P = 0.00$ $df_{3.56}$	$F = 29.7$ $P = 0.00$ $df_{3.56}$	$F = 29.8$ $P = 0.00$ $df_{3.56}$	$F = 39.0$ $P = 0.00$ $df_{3.56}$	$F = 60.0$ $P = 0.00$ $df_{3.56}$	$F = 81.0$ $P = 0.00$ $df_{3.56}$
Bemisia tabaci							
Egg	3.9 ± 0.17 aA	3.6 ± 0.19 aA	3.7 ± 0.15 aC	4.3 ± 0.21 bB	4.5 ± 0.16 bD	20.0 ± 0.1aB	23 ± 0.5 aA
1st Nymph	3.7 ± 0.15 bB	3.6 ± 0.15 bC	4.0 ± 0.16 aC	4.6 ± 0.13 aA	5.4 ± 0.13 aA	21.4 ± 0.2aA	24.0 ± 0.3 cC
3rd Nymph	3.5 ± 0.15 bB	3.6 ± 0.18 aD	4.2 ± 0.17 aC	4.0 ± 0.19 aA	4.1 ± 0.11bB	19.6 ± 0.1aA	19.5 ± 0.3 bB
ANOVA	$F = 1.4$ $P = 0.0259$ $df_{2.36}$	$F = 0.044$ $P = 0.957$ $df_{2.36}$	$F = 2.27$ $P = 0.119$ $df_{2.36}$	$F = 2.44$ $P = 0.102$ $df_{2.36}$	$F = 26.6$ $P = 0.00$ $df_{2.36}$	$F = 39.0$ $P = 0.00$ $df_{2.36}$	$F = 45.1$ $P = 0.00$ $df_{2.36}$
Aphis gossypii 1st nymph	3.65 ± 0.17 B	3.7 ± 0.23 A	3.3 ± 0.33 A	3.6 ± 0.26 A	4.4 ± 0.17 D	20.1 ± 0.32A	19.2 ± 0.62 B
ANOVA(all prey)	$F = 47.5$ $P = 0.00$ $df_{7.124}$	$F = 39.09$ $P = 0.00$ $df_{7.124}$	$F = 47.2$ $P = 0.00$ $df_{7.124}$	$F = 36.41$ $P = 0.00$ $df_{7.124}$	$F = 54.07$ $P = 0.00$ $df_{7.124}$	$F = 154.07$ $P = 0.00$ $df_{7.124}$	$F = 473.27$ $P = 0.00$ $df_{7.124}$

Means (± SE) within a column in small letter (between various stage in each prey tested) and with the capital letter (between all prey tested) followed by the same letter are not significantly different

Table 2 Mean consumption rate of *Macrolophus caliginosus* female fed on various stages of *Tuta absoluta*, *Bemisia tabaci* and *Aphis gossypii*

Prey	Consumption rate of (prey/day)						
	1st Nymphal instar	2nd Nymphal instar	3rd Nymphal instar	4th Nymphal instar	5th Nymphal instar	Total consumption	Adult
Tuta absoluta							
Egg	34.6 ± 1.12 aB	51.0 ± 1.29 aB	43.6 ± 1.52 aF	44.3 ± 1.08 aB	53.9 ± 1.13 aB	227.7 ± 0.1 aB	503.6 ± 6.7 aB
1st Larvae	7.0 ± 0.33 bD	7.9 ± 0.2 bD	7.0 ± 0.2 bE	8.2 ± 0.36 bF	9.7 ± 0.5 bD	39.66 ± 0.3 bG	76.4 ± 2. 1 bE
2nd Larvae	6.0 ± 0.26 bD	7.2 ± 0.4 bD	6.07 ± 0.3 bE	8.7 ± 0.22 bF	7.5 ± 0.2 aD	35.8 ± 0.5 cG	52.5 ± 0.9cF
3rd and 4th Larvae	2.3 ± 0.14 fC	2.6 ± 0.2 bC	4.3 ± 0.24 bB	5.3 ± 0.18 bG	5.6 ± 0.5 cD	20.07 ± 0.3 dH	38.3 ± 1.3 cG
ANOVA	$F = 564.2$ $P = 0.00$ $df_{3.56}$	$F = 983.4$ $P = 0.00$ $df_{3.56}$	$F = 497.09$ $P = 0.00$ $df_{3.56}$	$F = 926.16$ $P = 0.00$ $df_{3.56}$	$F = 1042$ $P = 0.188$ $df_{3.56}$	$F = 1033$ $P = 0.158$ $df_{3.56}$	$F = 3541$ $P = 0.00$ $df_{3.56}$
Bemisia tabaci							
Egg	55.7 ± 2.3 aA	95.3 ± 2.5 aA	102.6 ± 2.3 aA	115.3 ± 2.7 aA	195.5 ± 3.6 aA	564 ± 0.1 cA	715 ± 3.9aA
1st Nymph	15.0 ± 0.9 bC	11.2 ± 0.81 bD	12.7 ± 0.5 bD	22.3 ± 1.1 bD	41.7 ± 2.1 bB	102 ± 0.2 bD	335.7 ± 7.1bC
3rd Nymph	9.2 ± 0.3 cD	12.0 ± 0.65 bD	14.0 ± 0.3 bD	15.7 ± 0.6 cF	24.4 ± 0.6 bC	74.5 ± 0.3cE	194.5 ± 2.9cD
ANOVA	$F = 337$ $P = 0.00$ $df_{2.36}$	$F = 1130$ $P = 0.00$ $df_{2.36}$	$F = 1713$ $P = 0.00$ $df_{2.36}$	$F = 1112.6$ $P = 0.00$ $df_{2.36}$	$F = 1500$ $P = 0.00$ $df_{2.36}$	$F = 1700$ $P = 0.00$ $df_{2.36}$	$F = 1978$ $P = 0.00$ $df_{2.36}$
Aphis gossypii 1st nymph	4.7 ± 0.21 D	6.3 ± 0.21 D	8.7 ± 0.26D	10 ± 0.23 E	13.4 ± 0.3 C	43.2 ± 0.1 F	61.3 ± 1.6 E
ANOVA(all prey)	$F = 289.6$ $P = 0.00$ $df_{7.124}$	$F = 353.3$ $P = 0.00$ $df_{7.124}$	$F = 670$ $P = 0.00$ $df_{7.124}$	$F = 688.9$ $P = 0.00$ $df_{7.124}$	$F = 238.52$ $P = 0.00$ $df_{7.124}$	$F = 538.52$ $P = 0.00$ $df_{7.124}$	$F = 1798$ $P = 0.00$ $df_{7.124}$

Means (± SE) within a column in small letter (between various stage in each prey tested) and with the capital letter (between all prey tested) followed by the same letter are not significantly different

Table 3 illustrates that the developmental period of total immature stages and adult of *M. caliginosus* male were noticeably significantly the longest in case of fed on 1st nymph *B. tabaci* (20.9 ± 0.3 and 21.1 ± 0.4 day) compared to 1st nymph of aphids was 18.4 ± 0.3 and 19.2 days.

On the other side, the consumption rates of the nymph stages was significantly recorded as highest one when feeding on eggs of *B. tabaci* (571.7 prey/day) compared to 1st nymph of aphids was recorded at 51.5 prey/day (Table 4).

Discussion

The present study indicated that the polyphagous *M. Caliginosus* successfully preyed upon various stages of different preys: *T. absoluta*, *B. tabaci* and *A. gossypii* on tomato plants and their developmental period and consumption rate were affected by prey instars under laboratory conditions. Similar to the present results, Urbaneja et al. (2009) which studied the prey suitability of *T. absoluta*, eggs and larval instars under laboratory conditions to *Macrolophus pygmaeus* (Rambur) and *N. tenuis* Reuter in Spain. They found that both predators preyed actively on *T. absoluta* eggs and all larval stages, especially first-instar larvae.

Furthermore, Castane et al. (2004) noticed that the establishment population of mirid bugs in majority of greenhouses which was prevented treatment crops by chemical insecticide and that caused increased pupal mortality of white fly more than other predators in a survey.

Olivier et al. (2006) studied the predation choices of different *M. caliginosus* stages toward various developmental stages (eggs and nymphs) of whitefly *B. tabaci*. They found that *M. caliginosus* preferred older nymphs of *B. tabaci* than any other stages.

Mohd et al. (2009) indicated that *M. caliginosus* adults could be fed on all immature stages of the greenhouse whitefly, *Trialeurodes vaporariorum* without significant variation noticed in their consumption rate.

Generally, many authors recorded that the polyphagous mirid bugs prefers to feed on different kinds of prey as white fly (Lykouressis et al. 2009), or aphids (Perdikis and Lykouressis 2002) or/and moths such as *T. absoluta* (De Backer et al. 2014).

Calvo et al. (2012) and Pérez-Hedo and Urbaneja (2015), indicated that the mirid predator *Macrolophus pyamaeus* proved to be efficient predators against *B. tabaci* and *T. absoluta* in tomato fields.

Recently, integrated Pest Management (IPM) in tomatoes was interested by encouraging the researcher to develop Miridae bugs to increase the density of predators to overcome tomato white fly and other insect pest populations below the economic threshold (Mohd et al. 2009). The role of generalist natural enemies in biological

Table 3 Mean developmental period of *Macrolophus caliginosus* male fed on various stages of *Tuta absoluta*, *Bemisia tabaci* and *Aphis gossypii*

Prey	Developmental stages						
	1st Nymphal instar	**2nd Nymphal instar**	**3rd Nymphal instar**	**4th Nymphal instar**	**5th Nymphal instar**	**Total duration period of immature stage**	**Adult longevity**
Tuta absoluta							
Egg	2.9 ± 0.2 bC	2.5 ± 0.15 bD	2.6 ± 0.18 bC	4.1 ± 0.16 aC	3.5 ± 0.15 aD	15.75 ± 0.2 aD	15.5 ± 0.3 bD
1st Larvae	2.4 ± 0.16 bE	3.4 ± 0.16 aE	2.5 ± 0.2 cD	2.6 ± 0.2 bC	2.4 ± 0.22 aF	13.3 ± 0.3 bE	14.1 ± 0.3 aD
2nd Larvae	3.2 ± 0.2 aC	3.0 ± 0.33 aE	3.0 ± 0.2 cD	3.5 ± 0.17 aD	3.4 ± 0.17 aD	16.2 ± 0.5 aD	18.0 ± 0.4 bD
3rd and 4th Larvae	3.3 ± 0.18 aC	2.5 ± 0.19 aC	3.3 ± 0.14 aC	3.3 ± 0.14 aE	3.0 ± 0.24 aE	15.4 ± 0.2 aD	13.3 ± 0.4 bD
ANOVA	$F = 4.03$ $P = 0.00$ $df_{3.42}$	$F = 3.93$ $P = 0.00$ $df_{3.42}$	$F = 1.88$ $P = 0.00$ $df_{3.42}$	$F = 13.6$ $P = 0.00$ $df_{3.42}$	$F = 5.9$ $P = 0.00$ $df_{3.42}$	$F = 19.2$ $P = 0.00$ $df_{3.42}$	$F = 23.2$ $P = 0.00$ $df_{3.42}$
Bemisia tabaci							
Egg	3.5 ± 0.15 aA	3.6 ± 0.15 aA	3.6 ± 0.15 aB	3.9 ± 0.2 bC	3.7 ± 0.19 aBC	18.4 ± 0.2 aB	19.6 ± 0.4 aA
1st Nymph	4.07 ± 0.17 bB	3.6 ± 0.2 bb	4.0 ± 0.2 aB	4.6 ± 0.18 aA	4.5 ± 0.14 aB	20.9 ± 0.3 aB	21.1 ± 0.4 cC
3rd Nymph	3.5 ± 0.15 bB	3.9 ± 0.16 bb	4.2 ± 0.16 aB	4.0 ± 0.16 bB	4.0 ± 0.19 aC	19.63 ± 0.3 aC	17.9 ± 0.3 bB
ANOVA	$F = 3.55P = 0.00$ $df_{2.36}$	$F = 0.40$ $P = 0.000$ $df_{2.36}$	$F = 1.532$ $P = 0.00$ $df_{2.36}$	$F = 3.5$ $P = 0.00$ $df_{2.36}$	$F = 5.79$ $P = 0.00$ $df_{2.36}$	$F = 10.89$ $P = 0.00$ $df_{2.36}$	$F = 15.89$ $P = 0.00$ $df_{2.36}$
Aphis gossypii 1st nymph	3.45 ± 0.2 B	3.7 ± 0.3 A	3.27 ± 0.2 A	3.6 ± 0.3 AB	4.3 ± 0.6 CD	18.45 ± 0.3 A	19.27 ± 0.3 B
ANOVA (all prey)	$F = 37.5$ $P = 0.00$ $df_{7.104}$	$F = 29.09$ $P = 0.00$ $df_{7.104}$	$F = 37.2$ $P = 0.00$ $df_{7.104}$	$F = 26.41$ $P = 0.00$ $df_{7.104}$	$F = 64.07$ $P = 0.00$ $df_{7.104}$	$F = 124.07$ $P = 0.00$ $df_{7.104}$	$F = 463.27$ $P = 0.00$ $df_{7.104}$

Means (± SE) within a column in small letter (between various stage in each prey tested) and with the capital letter (between all prey tested) followed by the same letter are not significantly different

Table 4 Mean consumption rate of *Macrolophus caliginosus* male fed on various stages of *Tuta absoluta*,*Bemisia tabaci* and *Aphis gossypii*

Prey	Consumption rate of (prey/day)						
	1st Nymphal instar	**2nd Nymphal instar**	**3rd Nymphal instar**	**4th Nymphal instar**	**5th Nymphal instar**	**Total consumption**	**Adult**
Tuta absoluta							
Egg	32.0 ± 1.32 bC	42.1 ± 1.09 bD	39.4 ± 0.01 bC	42.2 ± 0.6 aD	50.1 ± 1.7 aD	206 ± 1.5 aD	433.1 ± 5.3 aB
1st larvae	6.1 ± 0.3 bE	8.4 ± 0.45 aC	5.9 ± 0.23 cD	7.8 ± 0.3 bE	8.2 ± 0.6 bF	36.4 ± 0.5 bE	58.0 ± 2.4 bG
2nd larvae	5.3 ± 0.4 aC	6.2 ± 0.32 aC	4.7 ± 0.27 cD	7.1 ± 0.4 aD	6.4 ± 0.3 aD	29.8 ± 1.3 bE	47.7 ± 1.5 cG
3rd and 4th larvae	2.7 ± 0.2 aC	2.9 ± 0.22 aE	4.2 ± 0.27 aC	5.1 ± 0.2 aD	6.5 ± 0.3 aE	21.58 ± 2.4 cE	30.6 ± 1.2 bG
ANOVA	$F = 329$ $P = 0.00$ $df_{3.42}$	$F = 790.4$ $P = 0.00$ $df_{3.42}$	$F = 860$ $P = 0.00$ $df_{3.42}$	$F = 1742$ $P = 0.00$ $df_{3.42}$	$F = 458$ $P = 0.004$ $df_{3.42}$	$F = 2616$ $P = 0.002$ $df_{3.42}$	$F = 3616$ $P = 0.002$ $df_{3.42}$
Bemisia tabaci							
Egg	50.9 ± 0.7 aA	81.18 ± 2.4 aA	97.8 ± 2.1 aA	105.18 ± 2.5 aA	175.6 ± 3.2 aA	510 ± 2.3 aA	571.7 ± 10.3 aA
1st Nymph	14.1 ± 0.9 bc	9.0 ± 0.3 bD	11.0 ± 0.5 bD	20.0 ± 1.02 bD	33.3 ± 0.7 bD	87.53 ± 3.5 bC	246.9 ± 9.3 aC
3rd Nymph	6.9 ± 0.2 cD	9.7 ± 0.3 bD	13.1 ± 0.4 bD	16.6 ± 0.6 bD	22.8 ± 0.5 bD	69.27 ± 2.2 bD	140.5 ± 1.8 cD
ANOVA	$F = 873.3$ $P = 0.00$ $df_{2.34}$	$F = 895.2$ $P = 0.000$ $df_{2.34}$	$F = 1535.15$ $P = 0.20$ $df_{2.34}$	$F = 998.7$ $P = 0.00$ $df_{2.34}$	$F = 2025$ $P = 0.54$ $df_{2.34}$	$F = 1697$ $P = 0.00$ $df_{2.34}$	$F = 697$ $P = 0.00$ $df_{2.34}$
Aphis gossypii 1st nymph	4.5 ± 0.5 D	5.3 ± 0.6 D	7. ± 6 0.9 D	10.2 ± 0.9 E	11.1 ± 0.1 D	39.18 ± 2.4 E	51.5 ± 13 E
ANOVA(all prey)	$F = 42.5$ $P = 0.00$ $df_{7.104}$	$F = 49.09$ $P = 0.00$ $df_{7.104}$	$F = 57.2$ $P = 0.00$ $df_{7.104}$	$F = 66.41$ $P = 0.00$ $df_{7.104}$	$F = 74.07$ $P = 0.00$ $df_{7.104}$	$F = 134.07$ $P = 0.00$ $df_{7.104}$	$F = 563.27$ $P = 0.00$ $df_{7.104}$

Means (± SE) within a column in small letter (between various stage in each prey tested) and with the capital letter (between all prey tested) followed by the same letter are not significantly different control was increased attention to (Symondson et al. 2002; Janssen and Sabelis 2015).They caused researchers to look more toward generalist predatory bugs instead of specialists to control aphids. Ongoing researches were focused on several predatory bugs that recorded effectiveness in aphid control in sweet pepper and mirid bugs proved to be better suited for this than anthocorid bugs, with *Macrolophus pygmaeus* Rambur (Heteroptera: Miridae) and *N. tenuis* showing very promising results (Perdikis and Lykouressis 2004; Messelink et al. 2011; Messelink and Janssen 2014; De Backer et al. 2015; Messelink et al. 2015; Pérez-Hedo and Urbaneja 2015; Bouagga et al. 2018).

Conclusions

The present research results demonstrated that the *M. caliginosus* female's developmental period was significantly longer when fed on the first nymphal instar of *B. tabaci* than the other pest eggs and consumed eggs of *B. tabaci* more than the other pests, and the male's developmental period was significantly longer when fed on the first nymphal instar of *B. tabaci* than the other pests and consumed 1st nymphal instar of *B. tabaci* more than the other pests. These predators might be employed in the future as biological control agents in greenhouses or in-filled tomato green house as part of an integrated pest management (IPM) program.

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Author contributions
This work was carried out in collaboration between all authors. HES involved in writing review and editing, writing methodology, formal analysis, data curation, and conceptualization. IMA involved in conceptualization, methodology, investigation, validation, formal analysis, data curation, writing review and editing, and writing original draft. SSM involved in resources, conceptualization, investigation, methodology, supervision, writing original draft, and writing review and editing. All authors have read and approved the manuscript.

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Availability of data and materials
All data are available in the article and the materials used in this work are of high quality and grade.

Declarations

Ethics approval and consent to participate
The manuscript does not contain studies involving human participants or human data.

Consent for publication
Not applicable.

Competing interests
All authors declare that they have no competing interest.

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