Role of the Predaceous Insects in Regulating the Population of the Main Piercing-Sucking Insect Pests Attacking Certain Vegetable Crops

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ABSTRACT:

The experiments were conducted to study the role of predaceous insects in regulating the population of vegetable crops insect pests at Kafr-Saad area, Damietta Governorate, Egypt during summer plantation of 2022. Nine predators belonging to four insect orders; i.e. Copleoptrea, Heteroptera, Diptera and Nuroptera were recorded on cucumber, cowpea, tomato and sweet potato. The coccinellid predators (*Coccinella undecimpunctata*, *C. septempunctata*, *Cryptolemus montiziri* and *Chilocorus nigritus*) were more abundant species on the tested host plants than the other predator species; *Orius* spp., *Macrolophus* sp., *Aphidoletes aphidimyza, Syrphus* sp. and *Chrysoperla carnea*. The coccinellid predators represented by 26.8, 29.7, 29.9 and 26.7% of the total number of predaceous insects in cucumber, cowpea, tomato and sweet potato crops, respectively. While, *Syrphus* sp. recorded the smaller number and represented by 5.4, 9.2, 11.2 and 10.6% of the total numbers of predatory insects on the previous crops. In respect to the preference of predators for the host plants, all predators greatly prefer cucumber (4504 predators / 25 leaves) followed by cowpea (757 predators / 25 leaves) and tomato (411 predators / 25 leaves) while, sweet potato plants showed a less preference for all predatory insects and represented by (292 predators / 25 leaves).

Keywords: Predatory insects, Vegetable crops, Piercing-Sucking Insects.

INTRODUCTION

Vegetables are very important for human nutrition; around 200 countries cultivate vegetables, which are a food source for people in many regions of the world, especially as providers of vitamins (C, A, B1, B6, B9, E), minerals, dietary fiber, and phytochemicals (Wargovich, 2000). Cucumber (*Cucumis sativus* L.) is one of the most important fresh vegetables consumed worldwide. In Egypt it is recently considered one of the most important vegetables grown in greenhouses and open field. The total cultivated area of open field cucumbers in 2018/2019 was 52.67 thousand acres and produced about 496.81 thousand tons of fresh fruits. The grain legume, cowpea (*Vigna unguiculata* L. Walp) is one of the most significant vegetables in Egypt. According to Belane and Dakora (2009), cowpea grain contains 23% protein and 57% carbohydrates, whereas the leaves contains 27-34% protein. Additionally, cowpea is a significant source of soil nitrogen, particularly in regions where low soil fertility is an issue (Sheahan, 2012). Tomato (*Lycopersicon esculentum*, mill) is one of the most important vegetable crops in Egypt and world. Egypt ranks as one of the largest tomato producers in the world. The total cultivated area of tomatoes in Egypt was about 490,260 acres in 2012 (FAO, 2012). Sweet potato, *Ipomoea batatas* (L.) is an important starchy food crop, especially in developing countries, where it ranks third in value of production and fifth in calorie contribution to human diets, and constitutes one of the seven most important crops on a worldwide basis (Jones 1970, Chalfant, *et al.* 1990, Jansson and Raman 1991 and FAO 2015).

Unfortunately, during its several growth phases, the aforementioned crops are attacked by a variety of insect pests. Injurious piercing-sucking insect pests seriously impair yield quality and quantity (Jackai, 1995; Ward *et al.*, 2002 and Hassan 2013). They inflict harm directly by suckling on plant juice, or indirectly by acting as viral vectors.

Chemical insecticides have negative consequences on the environment, domestic animals, people, and biological control agents (Schmutterer, 1990). Thus, biological control is still a crucial part in managing insect pests. In the case of vegetables, they are advised as they are almost certainly used as fresh foods. The Ministry of Agriculture has been working to reduce the amount of insecticides used in integrated pest management programs during the past few years. To maintain the natural balance, it is imported to conserve the natural enemies.

According to studies by Helal *et al*. (1996), Abd El-Kareim *et al*. (2011), Salman *et al*. (2014), Khuhro *et al*. (2012), and Al-Deghair *et al*. (2014), the primary cause of death for piercing-sucking insect pests (e.g., aphids, white fly, and leafhopper) is the aphidophagous predators. Predatory coccinellids are important bio-control agents because they feed on a range of phytophagous insect pests, including aphids, scale insects, mealy bugs, mites, white flies, thrips, etc., (Omkar and Pervez, 2002). Coccinellids are considered to be among the most important biological control agents (Ceryngier and Hodek, 1996). The mirid bug (family Miridae) is one of whiteflies main natural enemies. The omnivorous species in this family are significant natural adversaries of several pests in greenhouse crops and solanaceous fields, such as whiteflies (Albajes and Alomar, 1999). *Orius* spp. (Heteroptera: Anthocoridae) are native predators in Europe (van Lenteren, 1997). They can consume a variety of soft-bodied arthropods, including aphids (Reitz *et al.*, 2006). Also they can act as biocontrol agents, particularly in greenhouse environments (Rajabpour *et al.*, 2011; Salehi *et al.*, 2016). One of the largest families of order Diptera is Syrphidae, it is most famous for its amazing imitation of wasps and bees. The family Syrphidae has a wide range of feeding preferences; however the Syrphidae subfamily is a significant predator of aphids and other Homoptera as pests (Chambers, 1988). After bees, flies are typically the second most significant visitors to flowers (Larson *et al.*, 2001). *Aphidoletes aphidimyza* (Rondani) (Diptera: Cecidomyiidae) has been used as an effective biological control agent in greenhouses for more than 40 years. (Markkula 1963 and Harris 1973). The common green lacewing, *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae), is one of the most frequent arthropod predators. It feeds on a range of soft-bodied insects, including aphids, scale insects, whiteflies, mites, and the eggs and neonates of lepidopteron insects (McEwen *et al*. 2001).

The host plant has a significant impact on populations of piercing-sucking pests and their predators. The natural enemies displayed variations in their search characteristics in response to the species of host plant (Abd El-Kareim, 2002). In order to implement IPM programs, the host plant must be taken into account (Marouf, 2007 and Abdel-kareim *et al.*, 2011).

Therefore, the following topics were the focus of the current research:

1. Studying the seasonal abundance of the main predatory insect species and their prey (*Aphis* spp., *Bemisia tabaci, Thrips tabaci, Empoasca* sp., *Phenacoccus solenopsis* and *Nezara viridula*) on cucumber, cowpea, tomato and sweet potato crops.

2. Assessing the relationship between prey, host plants, and the seasonal activity of related predators.

MATERIALS AND METHODS

Field experiments:

A private farm located in Kafr-Saad area, Damietta Governorate, Egypt was used to study the relationship between the predatory insects; (*Coccinella undecimpunctata, C. septempunctata*, *Cryptolemus montiziri* and *Chilocorus nigritus*; *Orius* spp., *Macrolophus* sp., *Aphidoletes aphidimyza, Syrphus* sp. and *Chrysoperla carnea)* and piercing-sucking insect pests (*Aphis* spp., *Bemisia tabaci, Thrips tabaci, Empoasca* sp., *Phenacoccus solenopsis* and *Nezara viridula*) on different vegetable crops; i.e. cucumber crop, (*Cucumis sativus* L.: Cucurbitaceae); cowpea crop, (*Vigna unguiculata* (L.) Walp.: Fabaceae); tomato crop, (*Lycopersicon esculentum* Mill.: Solanaceae) and sweet potato crop, (*Ipomoea batatas* L. Lam: Convolvulaceae). To estimate the piercing-sucking insects seasonal abundance and predatory insects on the four vegetable plants; cucumber, cowpea, tomato and sweet potato, an area of about 1050 m2 was prepared, as recommended, and divided into four equal plots (each of 262.5 m^2), each plot was planted with one of the aforementioned vegetable crops. All vegetable crops were sown on the 27th of April 2022. All regular agricultural practices on the four crops were typically carried out without using pesticides. Throughout the whole production period, all recommended agricultural practices were adhered to, with the exception of using pesticides.

Sampling techniques:

After two weeks of planting date and continuing until harvest, weekly random samples of plants were taken from each replicate. After being placed in polyethylene bags in the field, leaves were collected and brought into the laboratory for analysis. The collected leaves were examined under a stereoscopic microscope. Insects were counted individually on both sides of the leaves. All of the previously stated insect species were counted and their numbers were noted. Predators were noted to have been present on the samples that were gathered. Predatory insects were counted on 25 plants in the field, in addition to leaf samples

Statistical analyses:

Utilizing SPSS Statistics (2020), simple correlation and multiple partial regression analyses were performed between prey densities (i.e., the weekly average of each prey density) and the seasonal abundance of insect predators.

RESULTS AND DISCUSSION

Relative abundance of vegetable crop insect pests:

The obtained results presented in Table (1) show that the vegetable crops i.e. cucumber, cowpea, tomato, and sweet potato were attacking by many insect species especially piercing-sucking insects. The insect species that were recorded belong to two insect orders: Thysanoptera, (*Thrips tabaci*) and Hemiptera, (*Aphis gossypii* and *Myzus persicae*); the tomato whitefly, *Bemisia tabaci* (Aleyrodidae); leafhoppers *Empoasca* spp. (Cicadellidae); the green stink bug *Nezara viridula* (L.) (Pentatomidae) and the cotton mealybug, *Phenacococcus solenopsis* Tinsley (Pseudococcidae).

Only five insect species, *A. gossypii, B. tabaci, Empoasca* spp., *P. solenopsis,* and *N. viridula* were recorded on each of the studied vegetable crops. The most attractive host plant was cucumber (attracted seven insect species) followed by cowpea and tomato (attracted six insect species) whereas sweet potato attracted five insect species.

The most abundant insect species on the studied vegetable crops were *Aphis* spp. recorded the highest number and ratio and presented by 242.4 individuals (51%). followed by the whitefly, *B. tabaci* presented by 161.4 individuals (34.1%). whereas, *N. viridula* was the smallest and represented by 3.2 individuals (0.7%) during the study season.

The relation between predatory insects and the tested host plants:

Total number and relative abundance of predatory insects:

The data in Table (2) and Fig. (1) show that there are nine predator species recorded on the four tested vegetable crops belonging to four orders: the first order is Copleoptrea (*Coccinella undecimpunctata, C. septempunctata, Cryptolemus montiziri* and *Chilocorus nigritus*), the second order is Heteroptera (*Orius* spp. and *Macrolophus* sp.), the third orders is Diptera (*Aphidoletes aphidimyza* and *Metasyrphus* sp.), Nuroptera was found to be the fourth order witch was represented by *Chrysoperla carnea* Table (2).

The data shown in Table (2) revealed that the most abundant predators on the tested host plants were the coccinellid followed by *Macroliphus* sp. and *Orius* spp. while, *A. aphidimyza* followed coccinillid only on cucumber plants while on the other three crops it came in fifth category. *Syrphus* sp. came in the last category of predaceous insects on all of the aforementioned crops. On the other hand, 26.8, 29.7, 29.9, and 26.7% of all predatory insects were coccinellid predators on cucumber, cowpea, tomato and sweet potato crops, respectively. While, *Syrphus* sp. recorded the smaller number and represented by 5.4, 9.2, 11.2 and 10.6% of the total numbers of predators in cucumber, cowpea, tomato and sweet potato crops, respectively, during the study season.

All predatory insects showed a preference for cucumber, followed by cowpea, while sweet potato plants showed a less preference for all predatory insects. This may be explained by the lower population density of insects that these predators feed on sweet potato plants compared to cucumber plants. The coccinellid predators preferred cucumber (1209 predators) in comparing with the other three host plants, cowpea (225 predators), tomato (123 predators) and sweet potato (78 predators), respectively (Table,1). On the other hand, Heteropteran predators, *Macroliphus* sp. and *Orius* sp. showed the same trend, *Macroliphus* sp. represented by 838, 146, 72 and 64 predators while, *Orius* sp. represented by 575, 119, 62 and 40 predators on cucumber, cowpea, tomato and sweet potato crops, respectively. Dipteran predators, showed the same trend, *Syrphus* sp. represented by 243, 70, 46 and 31 predators while, *A. aphidimyza* represented by 1056, 53, 32 and 21 predators on cucumber, cowpea, tomato and sweet potato crops, respectively. Nuropteran predator showed the same trend, *Chy. Carnea* population on cucumber, cowpea, tomato and sweet potato plants were 583, 144, 76 and 58 predators, respectively.

Seasonal abundance of predator species on different vegetable crops:

The Coleopteran predators:

Family Coccinellidae:

The data represented in Figure (2), showed that early than the other predators on May 16, the coccinellid predators began to visit cowpea and cucumber plants and recorded three peaks of infestation. The highest peak on cucumber (163 individual) were recorded in the 1st of Aug., while on cowpea and tomato the peak (28 and 16 individual) recorded on the 25th of Jul., The coccinellid predators appear later on June 6th on sweet potato plants, its peak recorded on July 18th with 11 indivi./ plant sample.

Nuropteran predators:

Family Chrysopidae:

As shown in Figure (2), the green lacewings *Chy. carnea* population recorded the highest numbers on the 13th of Jun. 2022 with 82 indivi./ plant sample on cucumber plants. While, on cowpea, tomato and sweet potato plants the highest number of individuals were recorded on Jul. 11 with 15, 9 and 7 indivi./ plant sample.

Dipteran predators:

A. Family: Cecidomyiidae:

The data represented in Figure (2), the aphidophagous gall midge, *Aphidoletes aphidimyza* (Rondani) started to visit the four vegetable crops after about nine weeks on 18th of Jul. and recorded the highest number on 1st of Aug. with 101 indiv. /sample on cucumber, while on cowpea, tomato and sweet potato plants the highest numbers recorded on Aug. 8 with 9, 5 and 4 individuals/ plant sample.

B. Family: Syrphidae:

The data represented in Figure (2) the syrphid predator, *Syrphus* sp. started to visit the four vegetable crops after about three weeks on 6th of Jun. and recorded the highest number on 8th of Aug. with 38, 9, 6 and 4 indivi./ plant sample on cucumber, cowpea, tomato and sweet potato plants respectively.

Heteropteran predators:

A. Family: Miridae:

The data represented in Figure (2), the mirid bug, *Macroliphus* sp. appeared on cucumber and cowpea crops on 23rd of May and on 30th of May on tomato and sweet potato while, exhibited a distinct peak on cucumber, cowpea and tomato plants (205, 24 and 13 individual/sample) recorded on the 4th of Jul. While on sweet potato plants the peak recorded on Jun. 27 with by 9 indivi./ plant sample.

B. Family: Anthocoridae:

The data represented in Figure (2), the anthocorids pirate, bugs *Orius* spp. appeared on cucumber and cowpea on 30th of May and on 6th of Jul. on tomato and sweet potato. One peak recorded on cucumber plants (97 individual/ sample) at the 27th of Jun. While, on cowpea, tomato and sweet potato plants the peak recorded on 18th of Jul. with 21, 12 and 7 individual/sample.

The relation between predatory insects and their prey.

Seasonal abundance of predators in response to prey density:

The data represented in Figures (3, 4, 5 and 6) show the population changes of each predator species in response to the densities of their prey on each host plant.

The interaction between seasonal activity of predators, preys and host plants.

Multiregression analysis was used to assess the relationship between the different prey densities and the seasonal activity of associated predatory insects on the examined host plants. The multi-regressions calculated values representing the common effect of average preys densities (i.e. thrips, whitefly, aphids, green stink bug, cotton mealybug and leafhoppers) on the population density of each predator on the four vegetable crops; cowpea, cucumber, sweet potato and tomato plants are displayed in Tables (3, 4, 5 and 6) which indicated to the following:

On cucumber crop:

Data presented in Table (3), show the relation between predaceous insect populations and tested prey on cucumber plants. In the case of coccinellid predators, this relation showed significant correlation with *Aphis* spp., *T. tabaci*, *Empoasca* spp. and *N. viridula* populations, the correlation coefficient value (r) = 0.524, -0.496, -0.588 and 0.632 respectively, while insignificant correlation with *B. tabaci* and *P. solenopsis* populations (r) =0.284 and 0.397. While, this relation in the case of *Macroliphus* sp. and *Orius* sp. were insignificant with all prey except *N. viridula* populations was highly significant and positive, the correlation coefficient value (r) = 0.612 and 0.771 respectively. On the other hand, *Syrphus* sp. this relation were highly significant with all prey except *Empoasca* spp. populations was insignificant and negative, the correlation coefficient value (r) = -0.373. Whereas, *A. aphidimyza* this relation were significant with *B. tabaci* and *T. tabaci* while, highly significant correlation with *P. solenopsis*, the correlation coefficient value (r) = 0.533, -0.445 and 0.772 respectively. Finally, *C. carnea* this relation were non-significant with each prey except *N. viridula* populations was significant and positive, the correlation coefficient value (r) =0.580.

As shown in (Table 3) multi-regression analysis revealed that the common effect of the prey population size (i.e. aphids, whitefly, thrips, leafhoppers, cotton mealybug and green stink bug) exhibited strong effect on the predatory insect populations.

The strongest effect shown in the case of *Syrphus* sp. (91.5%) and the weakest effect shown in the case of *C. carnea* predators (6.8%) of the overall population changes were caused by compound effect of the tested preys. Multi-regression analysis showed that the common effect of the population size of the aforementioned prey on the coccinellid, *Macroliphus* sp., *Orius* sp. and *A. aphidimyza* populations were 55.2, 50.0, 64.1 and 73.0% of the overall population changes were caused by the tested prey compound effect.

On cowpea crop:

Data presented in Table (4), show the relation between predaceous insect populations and tested prey on cowpea plants. In the case of coccinellid predators, this relation showed highly significant and positive correlation with *P. solenopsis* and *N. viridula* populations, the correlation coefficient value (r) = 0.938 and 0.930 respectively, while insignificant correlation with *Aphis* spp., *B. tabaci, T. tabaci* and *Empoasca* spp. populations. While, this relation in the case of *Macroliphus* sp. predator were significantly positive with *Aphis* spp. and *P. solenopsis* and highly significant with *Empoasca* spp. and *N. viridula*, the significantly coefficient value (r) = 0.581, 0.532, 0.622 and 0.790 respectively. This relation was insignificant with *B. tabaci* and *T. tabaci*. This relations in the case of *Orius* sp. predators with *P. solenopsis* and *N. viridula* insects were highly significant and positive, the correlation coefficient value (r) = 0.698 and 0.869 respectively, non-significant correlation were shown with the other insect species. On the other hand, the predatory insect, *Syrphus* sp. this relation was highly significant with *T. tabaci* and *P. solenopsis* and significant with *N. viridula* the correlation coefficient value (r) = -0.629, 0.702 and 0.498, while, it this relation was insignificant with *Aphis* spp., *B. tabaci* and *Empoasca* spp. Whereas, *A. aphidimyza* this relation was significant with *T. tabaci, Empoasca* spp and *P. solenopsis,* the correlation coefficient value (r) = -0.603, -0.566 and 0.461 respectively, while, non-significant correlation with *Aphis* spp, *B. tabaci* and *N. viridula*. The correlation coefficient value between *C. carnea* and each of *Aphis* spp. and *N. viridula* were highly significant and significantly positive with *B. tabaci,* the correlation coefficient value (r) = 0.644, 0.695 and 0.488 respectively, but it was insignificant with *T. tabaci, Empoasca* spp. and *P. solenopsis*.

As shown in (Table 4) multi-regression analysis revealed that the common effect of the prey population size (i.e. aphids, whitefly, thrips, leafhoppers, cotton mealybug and green stink bug) exhibited strong effect on the predatory insect populations.

The strongest effect shown in the case of coccinellid predators (91.3%) and the weakest effect shown in the case of *A. aphidimyza* predators (32.5%) of the overall population changes were caused by compound effect of the tested preys. Multi-regression analysis showed that the common effect of the population size of the aforementioned prey on the *Macroliphus* sp., *Orius* sp., *Syrphus* sp. and *C. carnea* populations were 79.3, 76.1, 54.6 and 72.6% of the overall population changes were caused by the tested prey compound effect.

On tomato crop:

Data presented in Table (5), show the relation between predaceous insect populations and tested prey on tomato plants. In the case of coccinellid predators, this relation showed highly significant correlation with *N. viridula* and significantly positive with *Aphis* spp. populations, the correlation coefficient value (r) = 0.932 and 0.512 respectively, while insignificant correlation with *B. tabaci, T. tabaci, Empoasca* spp. and *P. solenopsis* populations. While, this relation in the case of *Macroliphus* sp. predator was highly significant and positive with *N. viridula* and significantly negative with *P. solenopsis*, the correlation coefficient value (r) = 0.741 and -0.537 respectively. This relation was insignificant with *Aphis* spp., *B. tabaci, T. tabaci* and *Empoasca* spp. This relations in the case of *Orius* sp. predators with *N. viridula* insects were highly significant and positive, the correlation coefficient value (r) = 0.891, non-significant correlation were shown with the other insect species. On the other hand, the predatory insect, *Syrphus* sp. this relation was highly significant and positive with *Aphis* spp. and *N. viridula* and significant with *B. tabaci* and *T. tabaci,* the correlation coefficient value (r) = 0.746, 0.677, 0.514 and -0.587, while, it this relation was insignificant with *Empoasca* spp. and *P. solenopsis.* Whereas, *A. aphidimyza* this relation was highly significant and positive with *Aphis* spp. and significant with *B. tabaci, T. tabaci* and *P. solenopsis,* the correlation coefficient value (r) = -0.632, 0.533, -0.586 and 0.543 respectively, while, non-significant correlation with *Empoasca* spp. and *N. viridula.* The correlation coefficient value between *C. carnea* and *N. viridula* was highly significant and significantly positive with *Aphis* spp. and *Empoasca* spp., the correlation coefficient value (r) = 0.755, 0.584and 0.441 respectively, but it was non-significant with *B. tabaci, T. tabaci* and *P. solenopsis*.

As shown in (Table 5) multi-regression analysis revealed that the common effect of the prey population size (i.e. aphids, whitefly, thrips, leafhoppers, cotton mealybug and green stink bug) exhibited strong effect on the predatory insect populations.

The strongest effect shown in the case of *Syrphus* sp. followed by coccinellid and *Orius* sp. predators with 86.7, 85.4 and 82.3% of the overall population changes were caused by compound effect of the tested preys and the weakest effect shown in the case of *A. aphidimyza* predators (51.2%) of the overall population changes were caused by compound effect of the tested preys. While, *Macroliphus* sp. and *C. carnea*, multi-regression analysis showed that the common effect of the population size of the aforementioned prey were 56.7 and 53.3% of the overall population changes were caused by the tested prey compound effect.

On sweet potato crop:

Data presented in Table (5), show the relation between predaceous insect populations and tested prey on sweet potato plants. In the case of coccinellid predators, this relation showed highly significant correlation with *N. viridula* and significantly positive with *Aphis* spp. populations, the correlation coefficient value (r) = 0.934 and 0.508 respectively, while insignificant correlation with *B. tabaci, Empoasca* spp. and *P. solenopsis* populations. While, this relation in the case of *Macroliphus* sp. predator was highly significant and positive with *N. viridula* and significant with *B. tabaci, Empoasca* spp and *P. solenopsis*, the correlation coefficient value (r) = 0.838, 0.468, 0.489 and -0.517 respectively. This relation was insignificant with *Aphis* spp. This relations in the case of *Orius* sp. predators with *N. viridula* insects were highly significant and positive, the correlation coefficient value (r) = 0.942, non-significant correlation were shown with the other insect species, *Aphis* spp., *B. tabaci, Empoasca* spp and *P. solenopsis*. On the other hand, the predatory insect, *Syrphus* sp. this relation was highly significant and positive with *Aphis* spp. and *N. viridula,* the correlation coefficient value (r) = 0.729 and 0.621, while, it this relation was insignificant with *B. tabaci, Empoasca* spp. and *P. solenopsis*. Whereas, *A. aphidimyza* this relation was significantly positive with *Aphis* spp. and *P. solenopsis,* the correlation coefficient value (r) = 0.600 and 0.527 respectively, while, non-significant correlation with *B. tabaci, Empoasca* spp. and *N. viridula.*The correlation coefficient value between *C. carnea* and *N. viridula* was highly significant and significantly positive with *Aphis* spp., *B. tabaci* and *Empoasca* spp., the correlation coefficient value (r) = 0.791, 0.574, 0.478 and 0.489 respectively, but it was non-significant and negative with*, P. solenopsis*.

As shown in (Table 6) multi-regression analysis revealed that the common effect of the prey population size (i.e. aphids, whitefly, thrips, leafhoppers, cotton mealybug and green stink bug) exhibited strong effect on the predatory insect populations.

The strongest effect shown in the case of *Orius* sp. followed by coccinellid and *Macroliphus* sp. predators with 94.8, 89.0 and 81.6% of the overall population changes were caused by compound effect of the tested preys and the weakest effect shown in the case of *A. aphidimyza* predators (53.0%) of the overall population changes were caused by compound effect of the tested preys. While, *Syrphus* sp.and *C. carnea*, multi-regression analysis showed that the common effect of the population size of the aforementioned prey were 69.6 and 64.0% of the overall population changes were caused by the tested prey compound effect.

DISCUSSION

Attractiveness of different host plants to predatory insects

Surveying the predatory insects that associated with the summer planting season of the four vegetable crops (tomato, cucumber, cowpea and sweet potato) assured that the most abundant insect predators recorded were the coccinellid, (*Cryptolemus montiziri, C. septempunctata, C. undecimpunctata* and *Chilocorus nigritus*), *Orius* spp., *Macrolophus* sp., *A. aphidimyza, C. carnea* and *Syrphus* sp.

As previously noted by other authors, these predators were identified as important natural enemies of vegetable plants sweet potato, cucumber, cowpea, and tomato crops in Egypt, (Abdel-Gawaad *et al.,* 1990; Amro 2004; Ali *et* *al.*, 2013 and Gameel 2013 El-Fakharany, *et al.* 2017).

According to the current study, predaceous insects' seasonal abundance showed variations in their response to different host plants. The collected predators greatly preferred cucumber over cowpea, tomato and sweet potato. Also, the predacious insects; *C. motrouzari, Chilocorus bipustulatus* and *Rodolia cardinalis* showed differences in its response to different host plants (Cardosa, 1990; Heidari *et al*., 1999 and Abdel-Mageed, 2005). The average number of *C. undecimpunctata* and *Scymnus syriacus* showed significant differences between tomato cultivar Yassin *et al*. (2014).

According to El-Baradey (2012), differences in the type of Kairomone that produce by different plant species may cause in variation of predator response to different host plants. Abd El-Kareim (2002); Abdel-Kareim *et al*., (2011) and Marouf (2011) came to the same result, the main factor in insect attraction to host plant is emission of auditory stimuli. According to Luna and Jepson (2001), variations in hoverflies and coccinellid beetles response to the host plants under investigation could be caused by either chemical or physical stimulation. A combination of substances, including both the volatiles from the prey and the plants in the habitat, are involved for some predatory insects (Hagen, 1986). Satti and Mahgoub (2018) recorded four predators; the syrphid fly, *Xanthogramma aegyptium*, *C. undecimpunctata*, *C. carnea,* and *H. variegate* associated with *T. tabaci* on tomato, rocket, and onion plants. Even though hundreds of predators have been known to attack *B. tabaci*, the most frequent ones are as follows: lacewings (*C. carnea* and *C. pallens*), bugs (*Orius* sp., *Macrolophus caliginosus,* and *Nesidiocoris tenuis*), in addition to mites (*Amblyseius swirskii* and *Euseius ovalis*) Al-Zyoud (2014).

Interaction between predators activity, preys and host plants.

The geographical distributions of organisms within biological communities are significantly shaped by predator-prey interactions (Williams and Flaxman, 2012). Significant host-prey interactions were shown by Jalali and Michaud (2012) to be present for all aspects of development, including juvenile survival, developmental time, adult mass at emergence, and associated predator reproduction.

In this study, tested predatory insects, i.e. *Orius* species, Coccinellids, *Macrolophus* species, *Aphidimyza aphidimyza*, *Syrphus* species, and *C. carnea* showed differences in their response to the insect prey population on the different host plants, especially with populations of the leafhopper. When the coccinillid predator, *C. undecimpunctata* fed on the cotton aphid, *A. gossypii* showed higher rates of searching than when fed on the pomegranate aphid, *Aphis punicae* (Al-Deghair *et al*., 2014). Also, when the larval stage of the aphid lion, *Chrysoperla carnea* fed on the different aphid species (the English grain aphid, *Sitobion avenae,* the cotton aphid, *A. gossypii*, oleander aphid, *Aphis nerii* and corn aphid, *Rhopalosiphum maidis*) the total duration of the immature stages differed significantly (El-Serafi *et al*., 2000). According to Giles et al. (2002), the pea aphid *Acyrthosiphon pisum* fed on Alfalfa (*Medicago sativa*) it was suitable prey for the seven-spot ladybird (*C. septempunctata)* survival, developmental time, and size of the adult in comparing with the same species reared on the broad bean *(Vicia faba* L.) The developmental rate was significantly faster when the coccinillid predator, the seven-spot ladybird (*C. septempunctata*) was reared on *A. pisum* in comparing with the same species reared on *R. maidis* (Obrycki and Orr, 1990). According to Cottrell and Tillman (2017) four species of lady beetles (Coleoptera: Coccinellidae) exhibit limited predation on *N. viridula* eggs and nymphs.

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Table 1: Mean number and relative abundance of insect species during 2022 at Kafr-Saad region Damietta Governorate.

Host plant	*Aphis* spp.		*B. tabaci*		*T. tabaci*		*Empoasca* spp.		*P. solenopsis*		*N. viridula*		Total
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
Cucumber	890.1	52.5	631.2	37.2	142.4	8.4	6.4	0.4	24.6	1.5	1.8	0.1	1696.5
Cowpea	47.8	42.8	5.1	4.6	4.4	3.9	47	42.1	4.3	3.8	3.1	2.8	111.7
Tomato	29.7	46.9	5.4	8.5	11	17.4	3.9	6.2	9.9	15.6	3.4	5.4	63.3
Sweet potato	1.9	8.5	3.9	17.5	0.0	0.0	4.7	21.1	7.4	33.2	4.4	19.7	22.3
Mean	242.4	51.2	161.4	34.1	39.5	8.3	15.5	3.3	11.6	2.4	3.2	0.7	473.5

Table 2: Total number and relative abundance of predatory insect species on vegetable crops during 2022 at Kafr-Saad region Damietta Governorate.

Orders	Coleoptrea		Heteroptera				Diptera				Nuroptera		Total
Family	Coccinilidae		Miridae		Anthocoridae		Syrphidae		Cecidomyiidae		Chrysopidae		
Host plant	Coccilillid		*Macroliphus*sp.		*Orius sp.*		*Syrphus* sp.		*A. aphidimyza*		*C. carnea*		
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
Cucumber	1209	26.8	838	18.6	575	12.8	243	5.4	1056	23.4	583	12.9	4504
Cowpea	225	29.7	146	19.3	119	15.7	70	9.2	53	7.0	144	19.0	757
Tomato	123	29.9	72	17.5	62	15.1	46	11.2	32	7.8	76	18.5	411
Sweet potato	78	26.7	64	21.9	40	13.7	31	10.6	21	7.2	58	19.9	292
Mean	408.8	27.4	280.0	18.8	199.0	13.3	97.5	6.5	290.5	19.5	215.3	14.4	1491.0

Table 3: The correlation and regression coefficient between the predators (average number) and each of thrips, cotton mealybug, whitefly, leafhoppers, aphids, and green stink bug population densities on cucumber crop during 2022.

Predator	Prey	Simple correlation		Multiple partial regression				
		r.	P.	b.	p.	"F"	Prob>F	E.V.
Coccinillid	*Aphis* spp.	0.524	0.021	0.02	0.077	4.7	0.011	55.2%
	B. tabaci	0.284	0.238	-0.02	0.218			
	T. tabaci	-0.496	0.031	0.05	0.324			
	Empoasca spp.	-0.588	0.008	-4.34	0.147			
	P. solenopsis	0.397	0.093	0.95	0.063			
	N. viridula	0.632	0.004	14.06	0.064			
Macroliphus sp.	*Aphis* spp.	0.124	0.613	-0.01	0.663	4.00	0.02	50.0%
	B. tabaci	-0.251	0.300	0.01	0.640			
	T. tabaci	-0.217	0.371	-0.08	0.256			
	Empoasca spp.	-0.137	0.575	5.93	0.205			
	P. solenopsis	-0.386	0.103	-1.36	0.087			
	N. viridula	0.612	0.005	35.31	0.007			
Orius sp.	*Aphis* spp.	0.349	0.143	0.01	0.358	6.35	0.003	64.1%
	B. tabaci	-0.202	0.407	-0.01	0.648			
	T. tabaci	-0.306	0.202	-0.01	0.741			
	Empoasca spp.	-0.331	0.167	1.19	0.561			
	P. solenopsis	-0.279	0.247	-0.31	0.367			
	N. viridula	0.771	0.000	21.05	0.001			
Syrphus sp.	*Aphis* spp.	0.837	0.000	0.01	0.000	33.35	0.000	91.5%
	B. tabaci	0.675	0.002	0.01	0.777			
	T. tabaci	-0.485	0.035	0.03	0.558			
	Empoasca spp.	-0.373	0.116	-0.41	0.227			
	P. solenopsis	0.630	0.004	0.15	0.014			
	N. viridula	0.489	0.034	1.17	0.163			
A. aphidimyza	*Aphis* spp.	0.040	0.869	-0.01	0.713	9.09	0.001	73.0%
	B. tabaci	0.533	0.019	-0.01	0.482			
	T. tabaci	-0.445	0.056	0.01	0.962			
	Empoasca spp.	-0.413	0.079	-8.34	0.026			
	P. solenopsis	0.772	0.000	1.86	0.005			
	N. viridula	-0.038	0.877	-17.62	0.051			
C. carnea	*Aphis* spp.	0.389	0.100	0.01	0.552	1.22	0.362	6.80%
	B. tabaci	0.118	0.630	0.01	0.754			
	T. tabaci	-0.299	0.213	0.01	0.924			
	Empoasca spp.	-0.311	0.196	-0.42	0.854			
	P. solenopsis	0.030	0.903	-0.15	0.691			
	N. viridula	0.580	0.009	9.19	0.118			

Table 4: The correlation and regression coefficient between the predators (average number) and each of thrips, cotton mealybug, whitefly, leafhoppers, aphids, and green stink bug population densities on cowpea crop during 2022.

Predator	Prey	Simple correlation analysis		Multiple partial regression analysis				
		r.	P.	b.	p.	"F"	Prob>F	E.V.
Coccinillid	*Aphis* spp.	0.297	0.217	-0.014	0.537	32.390	0.000	91.3%
	B. tabaci	0.277	0.251	-0.062	0.735			
	T. tabaci	-0.359	0.131	-0.017	0.944			
	Empoasca spp.	0.122	0.619	-0.003	0.959			
	P. solenopsis	0.938	0.000	0.898	0.060			
	N. viridula	0.930	0.000	1.942	0.088			
Macroliphus sp.	*Aphis* spp.	0.581	0.009	0.083	0.033	12.470	0.000	79.3%
	B. tabaci	0.409	0.082	-0.423	0.151			
	T. tabaci	0.025	0.921	-0.153	0.680			
	Empoasca spp.	0.622	0.004	0.123	0.141			
	P. solenopsis	0.532	0.019	-0.414	0.543			
	N. viridula	0.790	0.000	2.687	0.119			
Orius sp.	*Aphis* spp.	0.233	0.338	-0.025	0.421	10.550	0.000	76.1%
	B. tabaci	0.255	0.293	-0.309	0.213			
	T. tabaci	-0.198	0.415	-0.072	0.821			
	Empoasca spp.	0.410	0.081	0.059	0.396			
	P. solenopsis	0.698	0.001	-0.177	0.760			
	N. viridula	0.869	0.000	2.775	0.065			
Syrphus sp.	*Aphis* spp.	0.198	0.416	0.019	0.343	4.610	0.012	54.6%
	B. tabaci	-0.104	0.672	-0.022	0.886			
	T. tabaci	-0.629	0.004	-0.274	0.202			
	Empoasca spp.	-0.363	0.127	0.011	0.806			
	P. solenopsis	0.702	0.001	0.651	0.104			
	N. viridula	0.498	0.030	-0.653	0.479			
A. aphidimyza	*Aphis* spp.	-0.123	0.616	-0.004	0.876	2.440	0.089	32.5%
	B. tabaci	-0.303	0.207	-0.119	0.578			
	T. tabaci	-0.603	0.006	-0.018	0.949			
	Empoasca spp.	-0.566	0.012	-0.059	0.337			
	P. solenopsis	0.461	0.047	0.222	0.666			
	N. viridula	0.222	0.361	0.345	0.781			
C. carnea	*Aphis* spp.	0.644	0.003	0.080	0.009	8.95	0.001	72.6%
	B. tabaci	0.488	0.034	-0.091	0.669			
	T. tabaci	-0.187	0.444	0.087	0.755			
	Empoasca spp.	0.296	0.219	-0.086	0.167			
	P. solenopsis	0.417	0.075	-1.499	0.011			
	N. viridula	0.695	0.001	3.943	0.007			

Table 5: The correlation and regression coefficient between the predators (average number) and each of thrips, cotton mealybug, whitefly, leafhoppers, aphids, and green stink bug population densities on tomato crop during 2022.

Predator	Prey	Simple correlation analysis		Multiple partial regression analysis				
		r.	P.	b.	p.	"F"	Prob>F	E.V.
Coccinillid	*Aphis* spp.	0.512	0.025	0.009	0.550	18.600	0.000	85.4%
	B. tabaci	0.306	0.203	-0.002	0.995			
	T. tabaci	-0.356	0.135	0.023	0.698			
	Empoasca spp.	0.312	0.194	-0.107	0.516			
	P. solenopsis	-0.082	0.740	0.071	0.414			
	N. viridula	0.932	0.000	1.870	0.000			
Macroliphus sp.	*Aphis* spp.	0.154	0.529	-0.022	0.362	4.920	0.009	56.7%
	B. tabaci	-0.148	0.546	0.066	0.879			
	T. tabaci	0.037	0.882	-0.044	0.650			
	Empoasca spp.	0.427	0.068	-0.147	0.583			
	P. solenopsis	-0.537	0.018	-0.211	0.149			
	N. viridula	0.741	0.000	1.239	0.017			
Orius sp.	*Aphis* spp.	0.277	0.251	-0.019	0.159	14.990	0.000	82.3%
	B. tabaci	0.026	0.916	0.028	0.904			
	T. tabaci	-0.158	0.519	-0.013	0.805			
	Empoasca spp.	0.313	0.193	-0.293	0.059			
	P. solenopsis	-0.369	0.120	-0.099	0.202			
	N. viridula	0.891	0.000	1.514	0.000			
Syrphus sp.	*Aphis* spp.	0.746	0.000	0.025	0.001	20.630	0.000	86.7%
	B. tabaci	0.514	0.024	-0.171	0.110			
	T. tabaci	-0.587	0.008	0.006	0.777			
	Empoasca spp.	0.039	0.873	0.024	0.708			
	P. solenopsis	0.347	0.145	0.126	0.002			
	N. viridula	0.677	0.001	0.527	0.000			
A. aphidimyza	*Aphis* spp.	0.632	0.004	0.030	0.025	4.150	0.017	51.2%
	B. tabaci	0.533	0.019	-0.121	0.567			
	T. tabaci	-0.586	0.008	0.005	0.907			
	Empoasca spp.	-0.263	0.277	-0.043	0.743			
	P. solenopsis	0.543	0.016	0.126	0.084			
	N. viridula	0.268	0.268	0.242	0.287			
C. carnea	*Aphis* spp.	0.584	0.009	0.032	0.096	4.43	0.014	53.3%
	B. tabaci	0.199	0.413	-0.141	0.656			
	T. tabaci	-0.257	0.289	-0.035	0.621			
	Empoasca spp.	0.441	0.059	0.251	0.216			
	P. solenopsis	-0.152	0.534	0.028	0.788			
	N. viridula	0.755	0.000	0.591	0.096			

Table 6: The correlation and regression coefficient between the predators (average number) and each of thrips, cotton mealybug, whitefly, leafhoppers, aphids, and green stink bug population densities on sweet potato crop during 2022.

Predator	Prey	Simple correlation analysis		Multiple partial regression analysis				
		r.	P.	b.	p.	"F"	Prob>F	E.V.
Coccinillid	*Aphis* spp.	0.508	0.026	0.025	0.849	30.150	0.000	89.0%
	B. tabaci	0.298	0.215	-0.590	0.671			
	Empoasca spp.	0.306	0.203	0.449	0.701			
	P. solenopsis	-0.038	0.876	0.072	0.071			
	N. viridula	0.934	0.000	0.978	0.000			
Macroliphus sp.	*Aphis* spp.	0.356	0.135	0.016	0.927	17.000	0.000	81.6%
	B. tabaci	0.468	0.043	-4.476	0.027			
	Empoasca spp.	0.489	0.034	3.714	0.0.29			
	P. solenopsis	-0.517	0.023	-0.116	0.033			
	N. viridula	0.838	0.000	0.732	0.000			
Orius sp.	*Aphis* spp.	0.368	0.121	0.071	0.286	66.020	0.000	94.8%
	B. tabaci	0.389	0.100	-0.264	0.702			
	Empoasca spp.	0.399	0.091	0.103	0.859			
	P. solenopsis	-0.439	0.060	-0.080	0.001			
	N. viridula	0.942	0.000	0.707	0.000			
Syrphus sp.	*Aphis* spp.	0.729	0.000	0.287	0.015	9.230	0.001	69.6%
	B. tabaci	-0.036	0.882	0.088	0.936			
	Empoasca spp.	-0.033	0.892	-0.113	0.903			
	P. solenopsis	0.315	0.189	0.064	0.048			
	N. viridula	0.621	0.005	0.264	0.006			
A. aphidimyza	*Aphis* spp.	0.600	0.007	0.291	0.042	5.060	0.009	53.0%
	B. tabaci	-0.182	0.455	1.476	0.299			
	Empoasca spp.	-0.191	0.433	-1.255	0.249			
	P. solenopsis	0.527	0.020	0.091	0.028			
	N. viridula	0.320	0.181	0.144	0.183			
C. carnea	*Aphis* spp.	0.574	0.010	0.284	0.112	7.400	0.002	64.0%
	B. tabaci	0.478	0.038	-1.359	0.453			
	Empoasca spp.	0.489	0.034	1.288	0.399			
	P. solenopsis	-0.146	0.552	0.041	0.401			
	N. viridula	0.791	0.000	0.375	0.014			

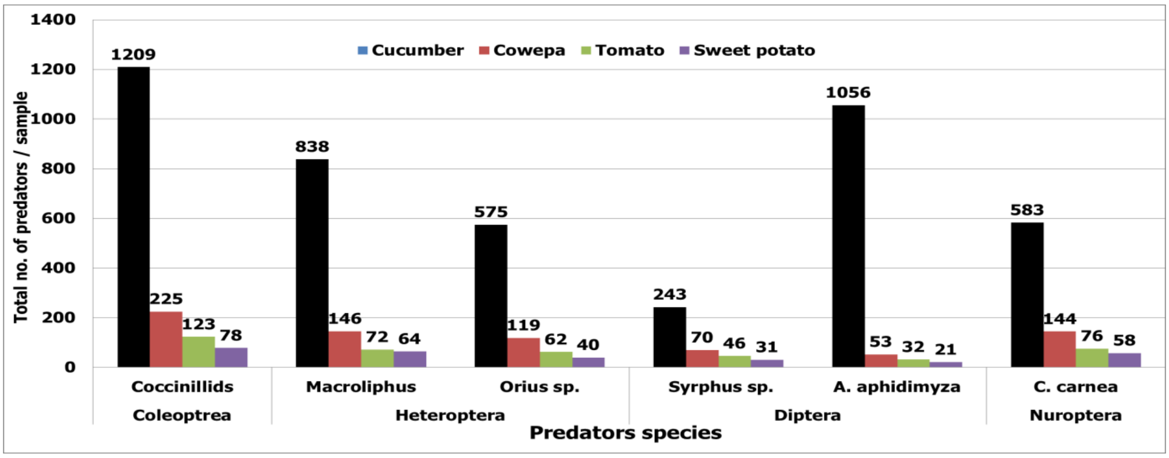


Figure 1: Seasonal mean number of the predaceous insects on the four vegetable crops during 2022 at Kafr-Saad region Damietta Governorate.

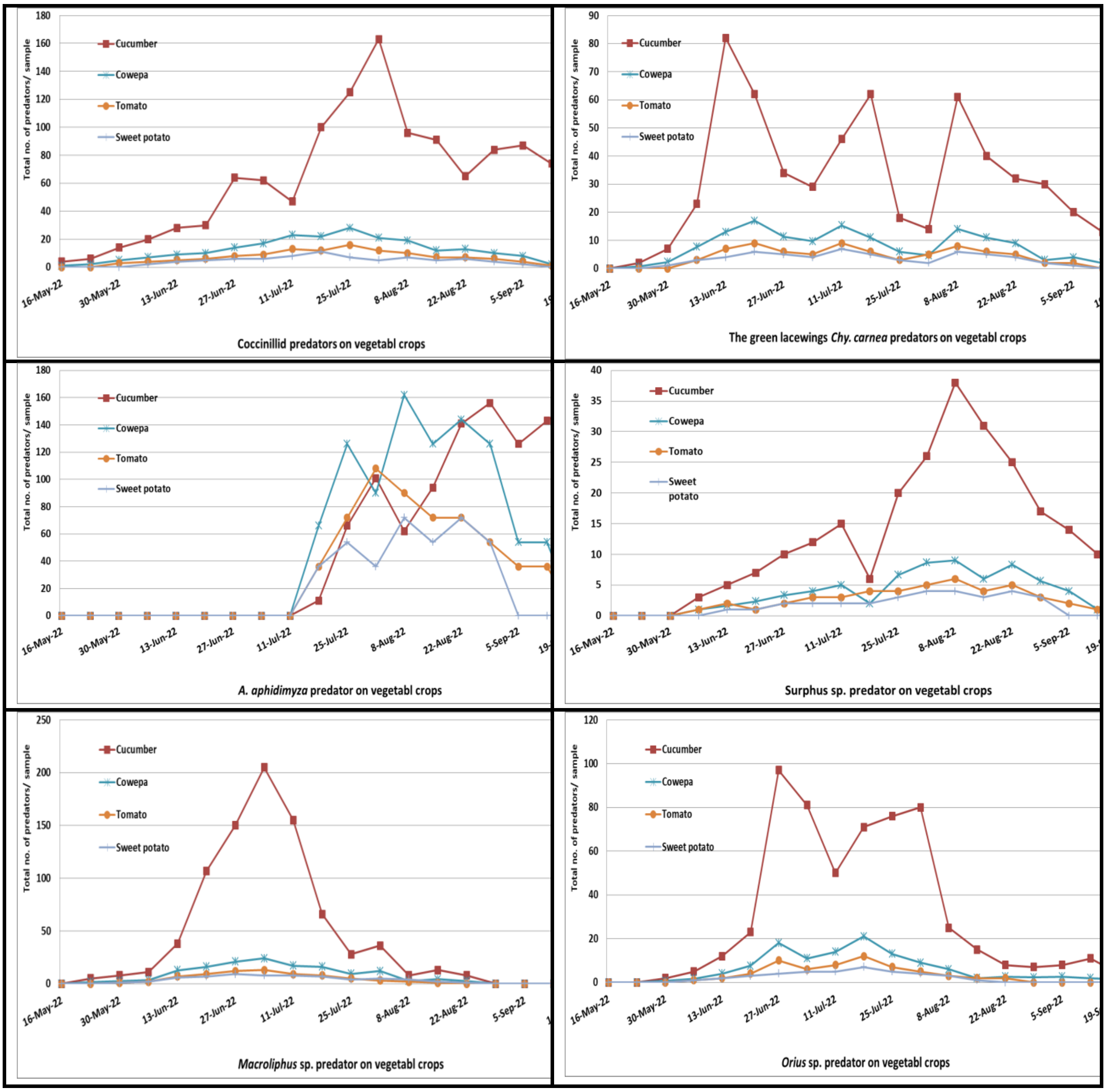
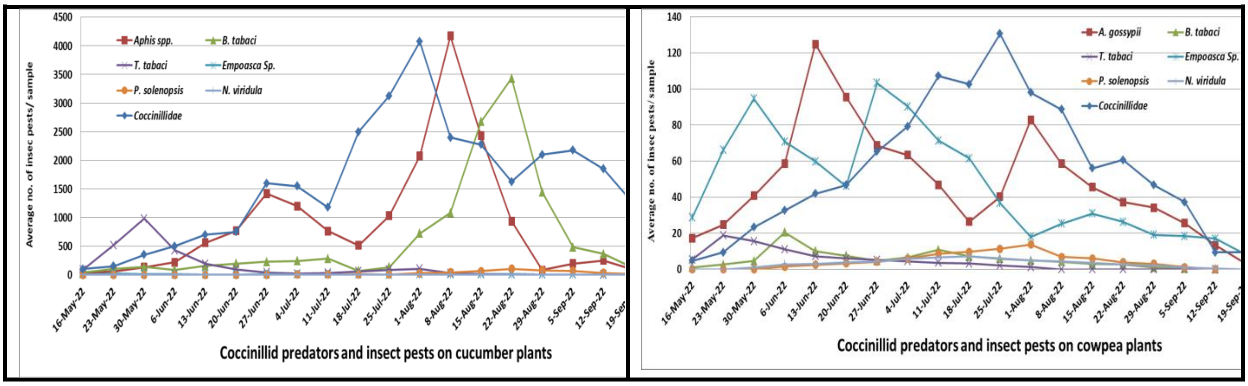


Figure 2: Seasonal abundance of predatory insects in response to host plants (Cucumber, cowpea, tomato and sweet potato) at Kafr-Saad region Damietta Governorate during 2022.



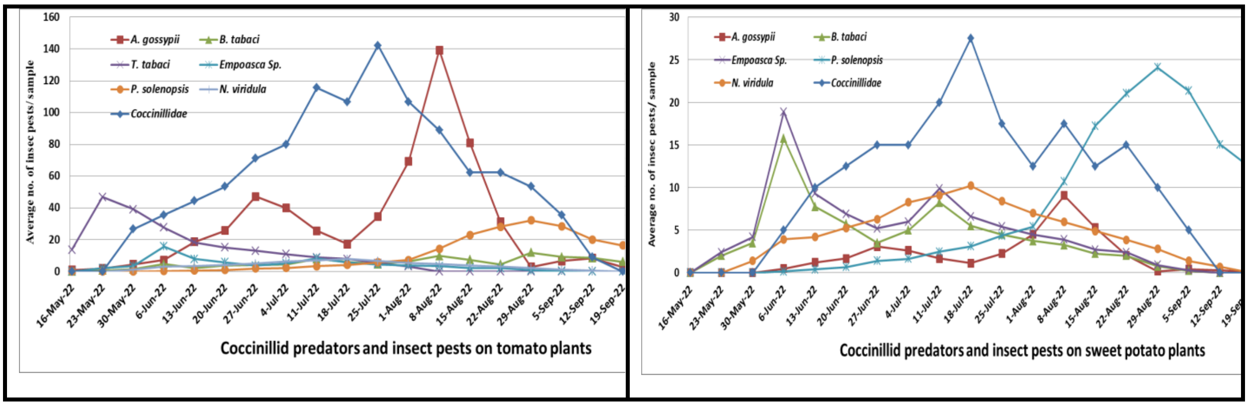


Figure 3: Seasonal abundance of the coccinillid predator in response to prey densities on cucumber, cowpea, tomato and sweet potato plants during 2022.

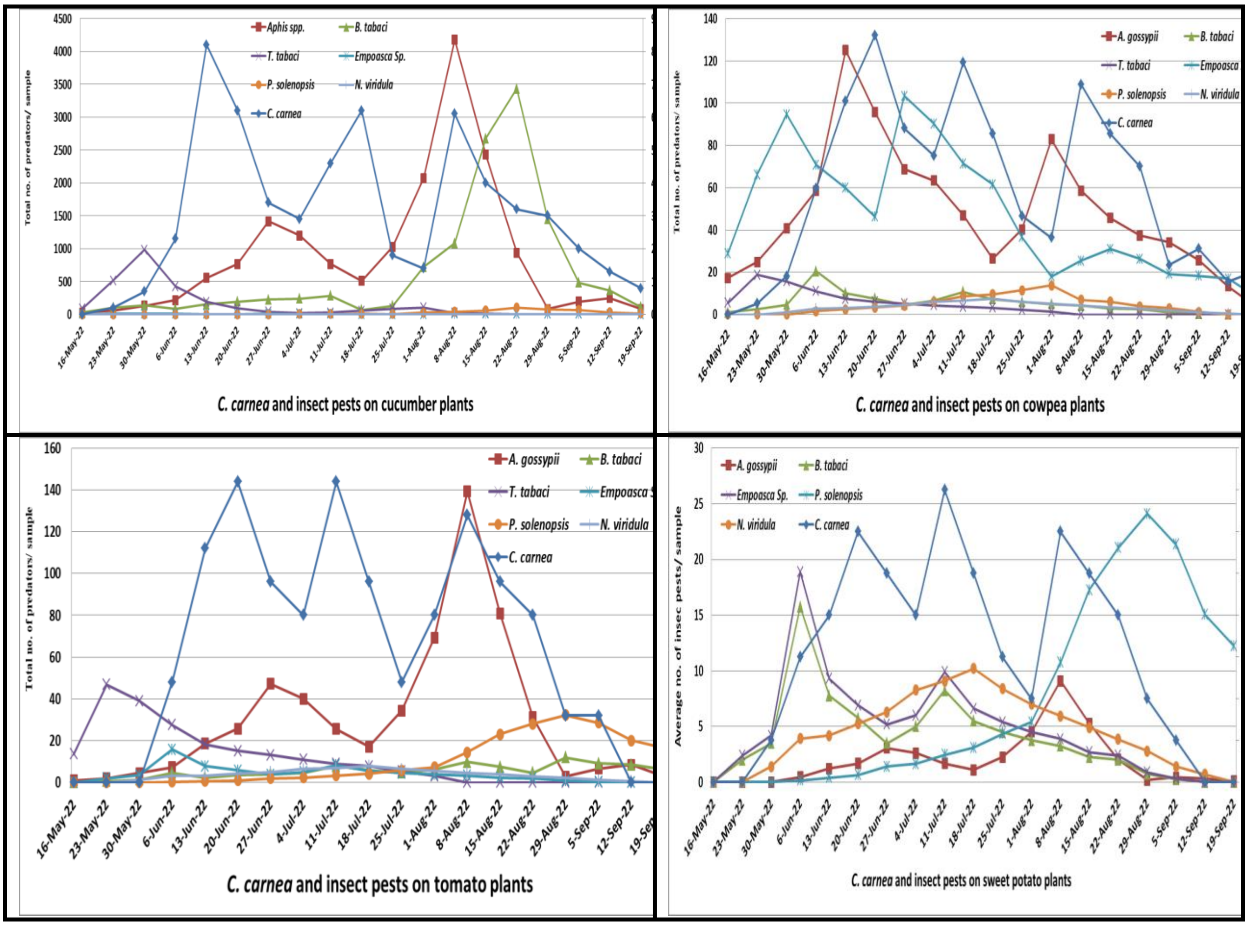


Figure 4: Seasonal abundance of the *C. carnea* predator in response to prey densities on cucumber, cowpea, tomato and sweet potato plants during 2022.

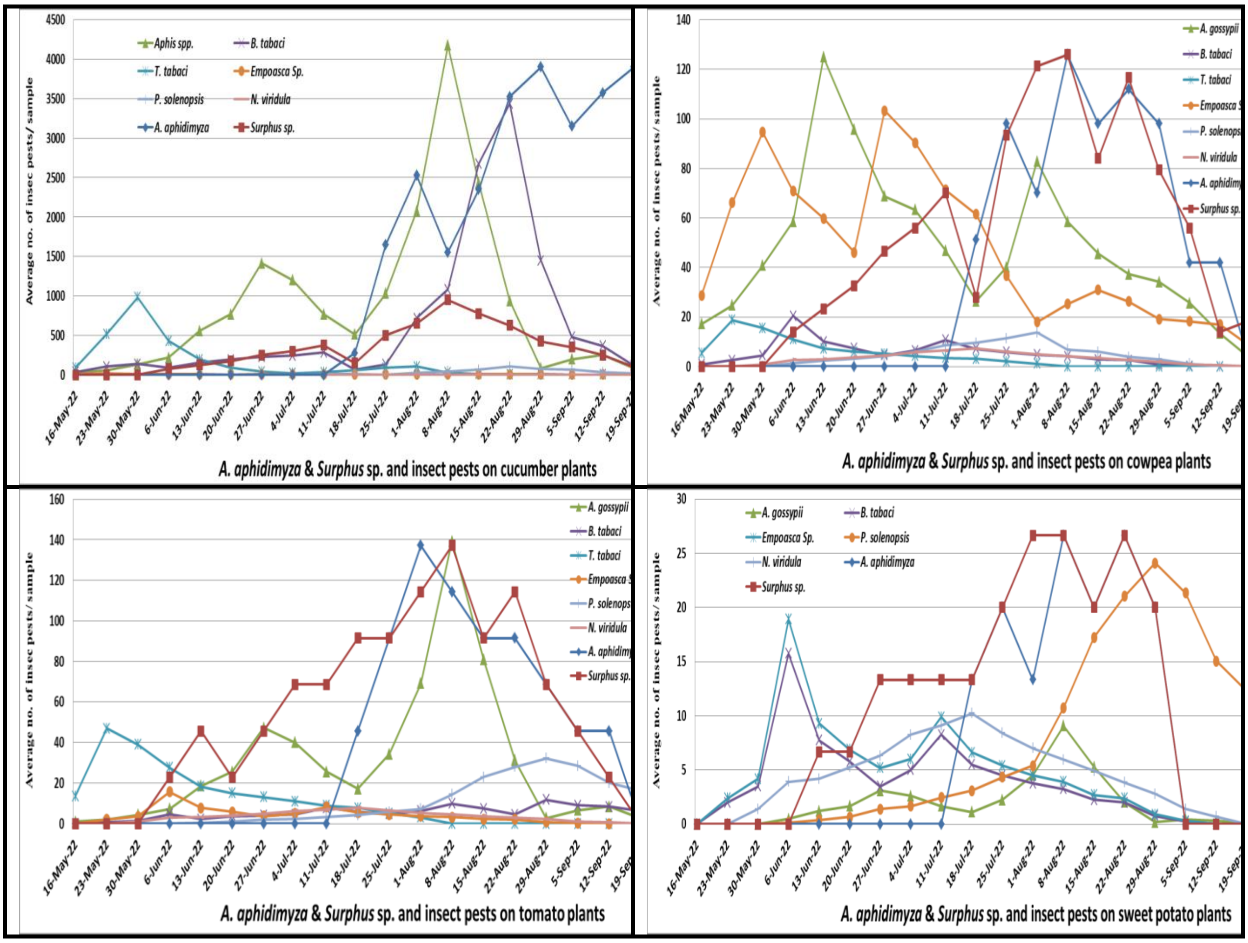


Figure 5: Seasonal abundance of the *A. aphidimyza* & *Surphus* sp. predator in response to prey densities on cucumber, cowpea, tomato and sweet potato plants during 2022.

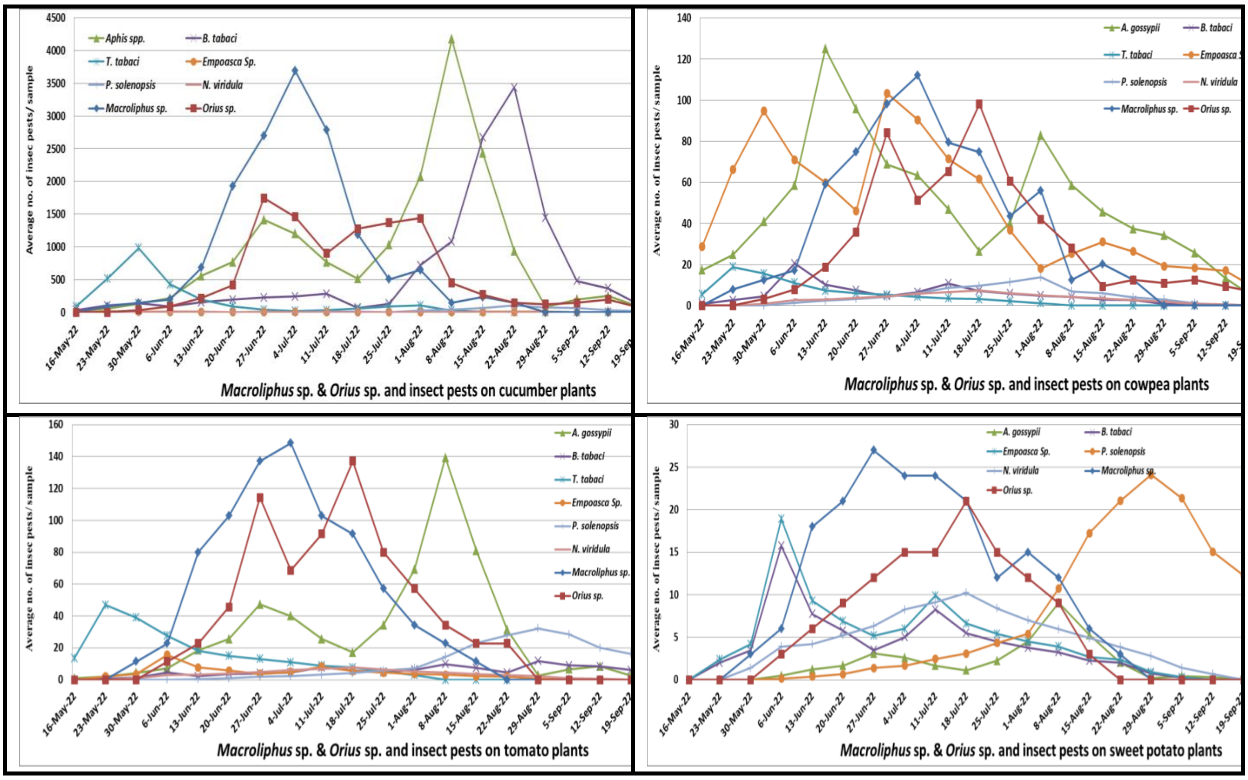


Figure 6: Seasonal abundance of the *Macroliphus* sp. & *Orius* sp.predator in response to prey densities on cucumber, cowpea, tomato and sweet potato plants during 2022 seasons.

دور الحشرات المفترسة في تنظيم تعداد الآفات الحشرية الثاقبة الماصة الرئيسية التي تهاجم بعض محاصيل الخضر

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الملخص العربي:

أجريت التجارب لدراسة دور الحشرات المفترسة في تنظيم مجاميع الآفات الحشرية الثاقبة الماصة على محاصيل الخضر في منطقة كفر سعد بمحافظة دمياط، مصر خلال موسم الزراعة الصيفى. أظهرت النتائج وجود تسعة مفترسات تنتمي إلى أربعة رتب حشرية هي ؛ غمدية الأجنحة، متباينة الأجنحة، ثنائية الأجنحة وشبكية الأجنحة على نباتات الخيار واللوبيا والطماطم والبطاطا الحلوة. وكانت مفترسات أبو العيد (أبو العيد أحد عشر نقطة *Coccinella undecimpunctata* ، أبو العيد سبع نقط *C. septempunctata* ، أبو العيد كريبتوليمس *Cryptolemus montiziri* وأبو العيد تشيلوكوروس *Chilocorus nigritus*) هى الأنواع الأكثر وفرة على العوائل النباتية المختبرة مقارنةً بكل من: بقة اوريس *Orius* spp. ، بقة ماكرولوفوس *Macrolophus* sp. ، ذبابة المن *Aphidoletes aphidimyza* ، ذبابة السيرفس *Syrphus* sp. وأسد المن *Chrysoperla carnea*. مثلت مفترسات عائلة أبو العيد 26.8 و 29.7 و 29.9 و 26.7 ٪ من إجمالي عدد الحشرات المفترسة على محاصيل الخيار واللوبيا والطماطم والبطاطا الحلوة على التوالي، بينما سجلت ذبابة السيرفس العدد الأصغر بنسبة 5.4 و 9.2 و 11.2 و 10.6٪ من إجمالي أعداد الحشرات المفترسة على المحاصيل السابقة. فيما يتعلق بتفضيل الحشرات المفترسة للعوائل النباتية ، إتضح أن جميع المفترسات تفضل نباتات الخيار (4504 مفترس/ 25 ورقة) تليها اللوبيا (757 مفترس/ 25 ورقة) والطماطم (411 مفترس/ 25 ورقة) في حين أظهرت نباتات البطاطا الحلوة تفضيلاً أقل لجميع الحشرات المفترسة ممثلةً بـ (292 مفترس/ 25 ورقة).

الكلمات الاسترشادية: المفترسات الحشرية، محاصيل الخضر، الحشرات الثاقبة الماصة.