EGYPTIAN ACADEMIC JOURNAL OF
BIOLOGICAL SCIENCES
ENTOMOLOGY

A

ISSN
1687-8809

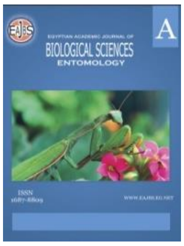
WWW.EAJBS.EG.NET

**Vol. 14 No. 3 (2021)**

Egypt. Acad. J. Biolog. Sci., 14(3):1-16(2021)

**Egyptian Academic Journal of Biological Sciences**
**A. Entomology**

**ISSN 1687- 8809**
**http://eajbsa.journals.ekb.eg/**




# Studies on Population Dynamic, Biology of The Cotton Mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) and Its Natural Enemies as A New Insect on Okra Plant, (*Abelmoschus esculentus* (L.) Moench) at Qena Governorate, Egypt

**Ghada S.Mohamed**
Plant Protection Department, Faculty of Agriculture, South Valley University, Qena, Egypt.
E-mail* : d.ghada1@yahoo.com

**ARTICLE INFO**
**Article History**
Received:30/5/2021
Accepted:9/7/2021
**Keywords**:
Mealybug, *Phenacoccus solenopsis*, *Ablmoschus esculentus*

## ABSTRACT

*Phenacoccus solenopsis* Tinsley is one of the most important insect pests that infested many important economic crops all over the world. The insect was recorded for the first time on the okra plants at the inception of March during the season of 2019 on the farm of the Faculty of Agriculture, South Valley University, Qena. Results of both seasons showed that the highest weekly population count of *P. solenopsis* was found during the first week of June. The highest percentages of the total monthly mean count were found to be 37.87and 39.56%, in June during the 1st and 2nd seasons, respectively. In addition, it has three generations per season under field conditions. The impact of some biotic and abiotic factors influencing the enumeration of *P. solenopsis* was studied. One species of wasp, *Aenasius arizonensis* (Girault) has been recorded as a parasitoid on *P. solenopsis*. The parasitism rate reached 12.31% during the first season. The predation rate reached 4.55% and it was attributed to the *Nephus includens* (Kirsch). Under laboratory conditions, the biology studies of *P. solenopsis* (Tinsley) were carried out on the sprouted potato plants. The results of the various biological factors recorded that the female fertility rate ranged between (310 to 650 eggs/female), which increases the survival rate. The female longevity reached (27.23±2.35 days) and the total life cycle ranged from 39-55 days. Accordingly, the information obtained from this study leads to the selection of appropriate means of management during the active reproductive period of *P. solenopsis.*

## INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is an agricultural crop that is mostly planted in tropical, semi-tropical, and hot areas of the world (Costa *et al*., 2018). In Egypt, okra is a substantial economic crop that enjoys great popularity because of its immature fruit crop, which has high nutritional and economic value, as well as a high ability to adapt to different environmental conditions (Priya *et al*., 2014). Okra fruits are the main exporter of many vitamins such as A, B, C, and some mineral salts (Gemede *et al*., 2015).

The mealybug, *Phenacoccus solenopsis* Tinsley (Homoptera: Pseudococcidae) is one of the most important insect pests that attack important economic crops in tropical and subtropical countries. It is polyphagous and infested more than 200 plant species from about 24 countries (Babasaheb and Suroshe, 2015). The cotton mealybug was recorded and

**Citation**: *Egypt. Acad. J. Biolog. Sci. (A. Entomology) Vol. 14(3) pp.1-16 (2021)*
**DOI: 10.21608/EAJBSA.2021.182944**

identified in Egypt for the primary time above weeds (Abd–Rabou *et al.,* 2010), and then it was recorded as a neoteric pest on tomato plants (Ibrahim *et al.,* 2015) and cotton plants (El-Zahi *et al.,* 2016). It was also observed that this type of mealybug was associated with 28 types of natural enemies, which included 16 parasitoids and 12 predators. *P. solenopsis* is a sucking insect pest and reported in high numbers with aggressive population behavior. The damage caused by infection with this type of mealybug is not limited to absorbing plant sap, but it is considered an important vector for many viral diseases. Also, the cotton mealybug secretes what is known as honeydew on the surfaces of the infested leaves of plants, which provides a fertile medium for the growth of black rot fungi that hinders the photosynthesis of these plants (Shah *et al.,* 2015). Due to the ability of this type of pest to cluster on the buds and apexes of plants and secrete a waxy layer on their bodies, controlling their population becomes extremely difficult using foliar insecticides.

Abiotic factors (temperature and relative humidity) had a very important influence on an organism, especially on biology, ecology, and population dynamics (Clark, 2003). Predators and parasites play the biggest role among the biotic factors affecting the population of *P. solenopsis*. *Aenasius arizonensis* (Girault), Encyrtidae (Hymenopter Chalcidoidea) is a solitary endoparasitoid of *P. solenopsis* beneath ordinary conditions, it is considered one of the most powerful active elements in biological control (Ahmed *et al.,* 2015; Shahzad *et al.,* 2016). This species of the parasitoid is characterized by a set of important characteristics, including the ability to adapt to different environmental conditions, and its life cycle is short and multiplies faster than its host and has a great ability to search for a host and its life cycle coincides with the life cycle of the host, and this species recorded a percentage of parasitism ranging between 5-100% (Fallahzadeh *et al.,* 2014). The parasitoid was counted and identified in different parts of the world, including USA, India, Pakistan, China, Iran, Egypt, Turkey and Iraq (Abdul- rassoul, 2018). The researchers Solangi and Mahmood (2011) studied the parasitoid, *A. arizonensis* ability to parasitize on six different types of mealybugs and their ability to grow and develop the parasitoid. The results proved that *P. solenopsis* is the appropriate type for the growth and development of the parasitoid while the parasitoid is unable to parasitize and grow on other types of mealybugs this means that the parasitoid has high specificity on *P. solenopsis*.

The *Nephus includes* (Kirsch) beetle (Coleoptera: Coccinellidae) is considered one of the most important predators for many types of mealybugs that cause great economic damage to agricultural crops and this species was recently recorded in Egypt (Abdel-Salam *et al*., 2010). Several previous studies have shed light on the importance of this coccinellid species as a predator. The use of this coccinellid predator can be a successful candidate against many types of mealybugs in open agricultural fields infested by these pests through rearing and release operations because of the high ability of this type of predator to search for prey and a good rate of its consumption **(**Izhevsky and Orlinsky, 1998; Kontodimas *et al*., 2004,2007).

The present research aimed to record *P.solenopsis* for the initial time on okra plants at Qena governorate in Egypt and its population dynamic, activity periods of different stages of *P. solenopsis* on okra plant. Study the impact of established biotic and abiotic elements on the population of *P. solenopsis*. The preferred leaf surface for that pest was determined and the number of generations was calculated during two seasons. Also, this study may contribute significantly to the development of an integrated program for pest management and many models to predict the population of *P. solenopsis.*

## MATERIALS AND METHODS

At the Faculty of Agriculture farm, South Valley University, Qena, Egypt, a few numbers of cotton mealybug were recorded in mid-July on okra plants (*Abelmoschus esculentus* (L.) Moench), cv Balady-Qena during the 2018 planting season. The incidence of this pest increased on okra plants during the 2019 season. Samples were collected from the different stages of that pest from the different parts of the infested okra plants in order to be identified in the identification unit of the Plant Protection Research Institute, Agricultural Research Center, Egypt.

The experiments were executed on an okra field existing at the Faculty of Agriculture farm, South Valley University, Qena, Egypt. The study was continued from the first week of February to the last week of July for two sequential seasons 2019 and 2020. The usual agricultural processes were applied in due time and all plots were kept without any insecticide treatments. After the plants reach the age of one month from the sowing dates, samples were taken weekly for counting and examination throughout the cultivation season.

To study the population dynamics of cotton mealybug, thirty leaves were picked randomly from four directions of the experimental area. These samples collected on the same day were examined in the laboratory by utilizing a stereomicroscope. During the examination process, the numbers of different stages of *P. solenopsis* were recorded on both upper and lower leaf surfaces.

The average number of each stage (Adult) was divided by the total number and multiplied by 100 to calculate the age composition of each sample. This method offered each phase (Adult) a percent ratio of the total per sample regardless of the total number of insects current (i.e. population density). Insect generation is described, as the duration needed to complete its life cycle. The number and duration of the annual generations of the pest, which were estimated depending on the adult numbers of the insect weekly count, were worked out according to Audemard and Milaire (1975) formula.

To facilitate making comparisons within each agricultural season and between the two agricultural seasons, the weekly numbers were accumulated monthly. The monthly numbers were calculated as a percentage of the total number of the season. From the meteorological data, the temperature and relative humidity associated with the date of sampling were recorded. The meteorological station from which the data were obtained is located in the experimental farm of the Faculty of Agriculture at South Valley University in the Governorate of Qena. To define the parasitoid associated with the pest, a plant sample consisting of (10 leaves) taken from (5 plants) was examined after examining those leaves in the laboratory to count the nymphs and the adults of the pest. Then, these leaves were kept in glass jars with a capacity of one kilogram (5 glass jars weekly). The jar was provided with an appropriate disc of filter paper on its floor to soak up condensed humidity. The mouth of these jars was covered with a piece of white gauze and secured with a rubber band. The emerged parasitoids are fed by placing a piece of cotton dipped in a 10% sucrose solution into a small plastic container placed inside glass jars. Extruded parasitoids were collected and preserved in small tubes containing 70% alcohol. By the Department of Biological Control of the Plant Protection Research Institute, the Agricultural Research Center, Giza, Egypt, this pest, Parasitoid, and predator accompanying it were identified.

During the weekly count of live insects by examining leaves samples, dead insects were also counted by the parasitoids (dead insects' bodies appear with small holes as a result of the exit of the parasites from them).

Using Van Driesche's equation (1983), the parasitism ratio was calculated as follows:

$$\%\ \text{parasitism ratio} = \frac{\text{Total parasitized hosts}}{\text{Total mealybug hosts}}$$

By using the multiple regression analysis, the relationships between the population size of each species of insects (pest, predator, and parasitoid) and the meteorological elements were analyzed and monitored using SPSS (version 25).

**Record of Biological Parameters:**

The cotton mealybugs were cultured in the laboratory on the shoots of potato tuber (Fisher, 1963). The biology of *P. solenopsis* was studied on potato buds, for germination of potato buds; they are wrapped in damp gunny at room temperature (25°C -70% R.H.) for 10 days. The cotton mealybugs were obtained from okra plants from the agriculture farm and transported to the laboratory. The cotton mealybugs were placed over the sprouts by using a soft brush of camel hair kept in fiber dishes (20 x 15 cm2) in the laboratory also at room temperature of (24-25°C -71.7% R.H.). Mass culture cotton mealybugs were obtained within 20 to 25 days. Newly hatched crawlers emerging from female eggs raised in the laboratory were collected and placed on potato sprouts. For this experiment, 10 replicates were made. Daily notes were recorded to calculate the time period between each molting of nymphs in order to determine the age stages of the nymphs and their duration. Pre-oviposition, oviposition, and post-oviposition period in the case of females and longevity of females were registered.

## RESULTS AND DISCUSSION

The current study is the first to count and record *P.solenopsis* Tinsley on okra plants during the 2019 and 2020 agricultural seasons in Qena Governorate. Photographs that are shown in Figure (1) appeared to be infested with *P.solenopsis* on different parts of the okra plant.

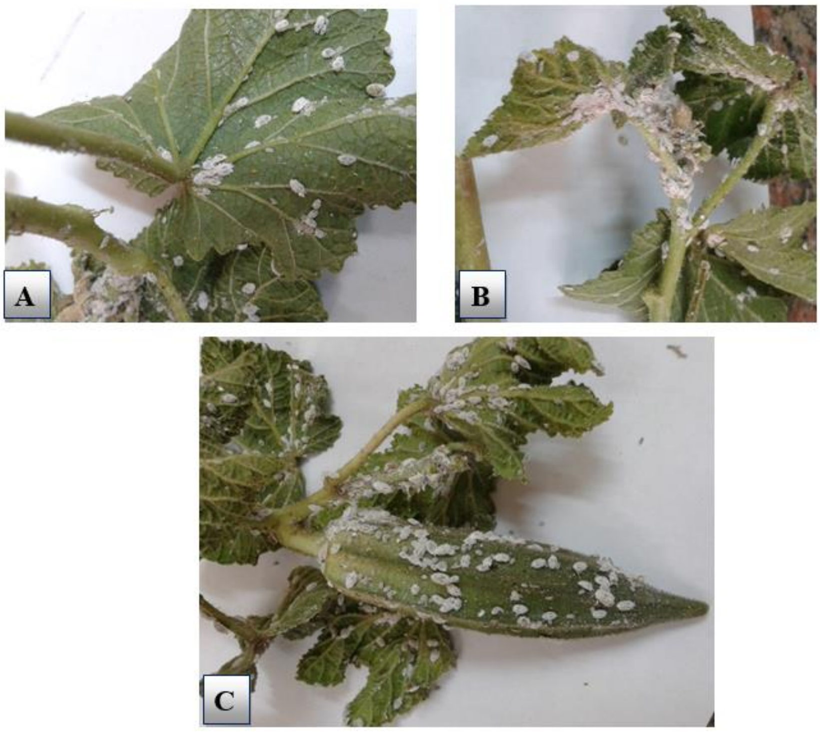



**Fig. 1.** Photographs showing the infestation of okra plants by *P. solenopsis* : A – adult and nymphs of *P. solenopsis* on leaves; B – adult and nymphs of *P. solenopsis* on stem; C – adult and nymphs of *P. solenopsis* on based buttons of the fruit.

**Population Dynamic of *P. solenopsis*:**

Data presented in Tables (1&2) showed the weekly population counts of the cotton mealybug (nymphs and adults) on okra leaves during both seasons of 2019 and 2020.

**1. 2019 Season:**

Table 1 showed that the population of a pest (nymphs and adults) began with 10 nymphs and 6 adults /30 leaves, on the 2nd week of March. The insect population was then very slightly increased till the end of March. After that, the cotton mealybug population increased gradually to reach its highest level during the 1st week of June for nymphs (704 individuals/30 leaves), and during the 3rd week of June for adults (117 individuals/30 leaves). Population numbers decreased after that, but only slightly until late July.

Data in Table 3 showed the total monthly mean counts of the pest on okra leaves and their percentages. The highest percentage of the total monthly average was recorded in June (37.87%), followed by (34.20%) in May.

**2. 2020 Season:**

In the second season, the same trend was noticed population fluctuations of the pest on okra leaves during the 2nd season Table 2. The population of the insect started with 33 and 10 individuals/30 leaves (nymphs and adults), during the 2nd week of March. Then, the pest population showed an increase, but in a little noticeable way till reaching its highest level during the last week of May and the 1st week of June (1701 and 162 individuals/30 leaves for nymphs and adults). Then, the pest population decreased very slightly and gradually till the end of the season.

Data in Table 3 showed that the highest monthly percentages were recorded during June (39.56% of the total season count) followed by May (36.19 %).

**Table 1:** Population fluctuation of *P. Solenopsis* Tinsley its Parasitoid, *Aenasius arizonensis* (Girault) and its predator, *Nephus includens* (Kirsch) on okra pant at Qena governorate during 2019 season.

| Month and year | Date | Weakly insect count/ 30 leaves | | | | | % Parasitism | % Predates | Meteorological records | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Nymphs | Adults | Total | Parasitized individuals | Predated individuals | | | Temperature (°C) | | R.H |
| | | | | | | | | | Max. | Min. | % |
| March, 2019 | 10 | 10 | 6 | 16 | 0 | 0 | 4.29 | 2.86 | 33.2 | 11.4 | 55.94 |
| | 17 | 25 | 13 | 38 | 0 | 0 | | | 34.8 | 10.6 | 58.14 |
| | 24 | 48 | 19 | 67 | 0 | 0 | | | 28.5 | 11.2 | 60.61 |
| | 31 | 69 | 20 | 89 | 9 | 6 | | | 30.6 | 10.11 | 52.4 |
| Total | | **152** | **58** | **210** | **9** | **6** | | | | | |
| April | 7 | 88 | 21 | 109 | 22 | 14 | 12.31 | 4.55 | 35.8 | 11.18 | 48.17 |
| | 14 | 157 | 30 | 187 | 28 | 11 | | | 31.14 | 10.11 | 52.18 |
| | 21 | 207 | 51 | 258 | 31 | 10 | | | 31.18 | 14.18 | 55.2 |
| | 28 | 347 | 66 | 413 | 38 | 9 | | | 40.11 | 15.21 | 56.18 |
| Total | | 799 | 168 | 967 | 119 | 44 | | | | | |
| May | 5 | 508 | 81 | 589 | 41 | 15 | 6.95 | 2.66 | 41.18 | 14.18 | 58.17 |
| | 12 | 584 | 89 | 673 | 47 | 17 | | | 44.16 | 16.6 | 61.14 |
| | 19 | 611 | 93 | 704 | 50 | 21 | | | 38.2 | 13.11 | 60.8 |
| | 20 | 642 | 97 | 739 | 50 | 19 | | | 40.18 | 15.18 | 55.31 |
| Total | | **2345** | **360** | **2705** | **188** | **72** | | | | | |
| June | 2 | 704 | 103 | 807 | 53 | 22 | 7.98 | 2.35 | 41.9 | 11.6 | 60.3 |
| | 9 | 681 | 111 | 792 | 61 | 14 | | | 44.21 | 10.3 | 58.14 |
| | 16 | 674 | 117 | 791 | 60 | 18 | | | 45.11 | 15.9 | 55.2 |
| | 23 | 655 | 94 | 749 | 68 | 20 | | | 38.1 | 10.16 | 61.14 |
| | 30 | 516 | 90 | 606 | 57 | 14 | | | 39.2 | 16.34 | 65.15 |
| Total | | **3230** | **515** | **3745** | **299** | 88 | | | | | |
| July | 7 | 406 | 85 | 491 | 28 | 14 | 7.27 | 4.07 | 46.18 | 20.8 | 44.36 |
| | 14 | 217 | 64 | 281 | 22 | 10 | | | 44.11 | 18.16 | 38.17 |
| | 21 | 118 | 50 | 168 | 19 | 10 | | | 40.08 | 15.11 | 41.38 |
| | 28 | 64 | 28 | 92 | 6 | 8 | | | 38.17 | 14.16 | 42.19 |
| Total | | **805** | **227** | **1032** | **75** | **42** | | | | | |
| Total | | 7331 | 1328 | 8659 | 690 | 252 | | | | | |

**Table 2:** Population fluctuation of *P. Solenopsis* Tinsley its Parasitoid, *Aenasius arizonensis* (Girault) and its predator, *Nephus includens* (Kirsch) on okra pant at Qena governorate during 2020 season.

| Month and year | Date | Weakly insect count/ 30 leaves | | | | | % Parasitism | % Predates | Meteorological records | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Nymphs | Adults | Total | Parasitized individuals | Predated individuals | | | Temperature (°C) Max. | Temperature (°C) Min. | R.H % |
| March,2020 | 15 | 33 | 10 | 43 | 3 | 0 | 7.81 | 0.00 | 35.14 | 17.3 | 51.13 |
| | 22 | 41 | 14 | 55 | 7 | 0 | | | 38.11 | 15.2 | 50.11 |
| | 29 | 72 | 22 | 94 | 5 | 0 | | | 30.55 | 11.4 | 48.13 |
| Total | | **146** | **46** | **192** | **15** | **0** | | | | | |
| April | 5 | 97 | 31 | 128 | 20 | 3 | 10.57 | 2.60 | 38.11 | 15.15 | 55.1 |
| | 12 | 203 | 58 | 261 | 22 | 5 | | | 37.19 | 14.11 | 50.61 |
| | 19 | 317 | 71 | 388 | 44 | 11 | | | 40.15 | 21.15 | 66.18 |
| | 26 | 441 | 88 | 529 | 52 | 15 | | | 38.11 | 20.06 | 48.16 |
| Total | | **1058** | **248** | **1306** | **138** | **34** | | | | | |
| May | 3 | 618 | 97 | 715 | 46 | 20 | 6.93 | 3.21 | 44.18 | 17.61 | 51.17 |
| | 10 | 724 | 118 | 842 | 51 | 27 | | | 40.2 | 16.09 | 60.2 |
| | 17 | 955 | 121 | 1076 | 68 | 38 | | | 38.11 | 16.11 | 53.18 |
| | 24 | 1224 | 144 | 1368 | 84 | 49 | | | 40.07 | 19.3 | 50.09 |
| | 31 | 1603 | 157 | 1760 | 90 | 51 | | | 35.17 | 15.11 | 48.15 |
| Total | | **5124** | **637** | **5761** | **339** | **185** | | | | | |
| June | 7 | 1701 | 162 | 1863 | 94 | 61 | 5.80 | 2.92 | 41.2 | 18.2 | 55.18 |
| | 14 | 1308 | 138 | 1446 | 81 | 35 | | | 45.18 | 20.18 | 60.1 |
| | 21 | 911 | 107 | 1018 | 75 | 30 | | | 44.11 | 19.11 | 68.17 |
| | 28 | 625 | 86 | 711 | 42 | 21 | | | 41.19 | 20.11 | 58.51 |
| Total | | **4545** | **493** | **5038** | **292** | **147** | | | | | |
| July | 5 | 517 | 102 | 619 | 35 | 21 | 6.95 | 3.87 | 45.6 | 20.61 | 54.65 |
| | 12 | 408 | 81 | 489 | 31 | 18 | | | 46.18 | 21.14 | 51.44 |
| | 19 | 218 | 40 | 258 | 22 | 11 | | | 44.09 | 19.18 | 62.14 |
| | 26 | 122 | 37 | 159 | 18 | 9 | | | 41.17 | 18.68 | 60.28 |
| Total | | **1265** | **260** | **1525** | **106** | **59** | | | | | |
| Total | | 12138 | 1684 | 13822 | 890 | 425 | | | | | |

**Table 3:** The monthly mean count of *P. Solenopsis* and their percentages out of the total season count during 2019 and 2020 seasons

| Month | 2019 Season | | 2020 Season | |
|---|---|---|---|---|
| | Mean monthly count / 30 leaves | % Out of the total season count | Mean monthly count / 30 leaves | % Out of the total season count |
| **March** | 52.5 | 2.65 | 64 | 2.01 |
| **April** | 241.75 | 12.23 | 326.5 | 10.26 |
| **May** | 676.25 | 34.2 | 1152.2 | 36.19 |
| **June** | 749 | 37.87 | 1259.5 | 39.56 |
| **July** | 258 | 13.05 | 381.25 | 11.98 |
| **Total** | 1977.5 | 100 | 3183.45 | 100 |

The results of both agricultural seasons showed that the highest weekly number of this pest was recorded in the first week of June. Also, during the same month, the highest percentage of the total average monthly pest population was recorded. At Giza governorate, Egypt, Elbahrawy *et al*. (2020) stated that the population of *P. solenopsis* increased and reached its highest level of abundance during the 2$^{nd}$ week of June on Tomato (*Solanum lycopersicum* L.), after which the population declined gradually. Although, these results are in full agreement with our results concerning the decline of the pest population after June but differed concerning the period of highest population. The differentiation between our results and their results may be due to the differentiation in the kind of host plants and in the geographical and consequently climatic nature of the district of study. In Pakistan, (Sahito *et al.*, 2011) the highest rate of infestation with *P. solenopsis* was recorded on cotton plants within a month of September and October, while Shahid *et al.* (2012) recorded the peak of the cotton mealybug population in August and September. Generally, work on

*P. solenopsis* unlike most other species of mealybugs is very limited except when someone surveyed the insects infesting any host plant and surveying this pest among the surveyed pests. Some other authors have worked on some other Pseudococcidae pests and reached the same logic. (Ahmed and Adb-Rabou, 2010) have proven that the abundance of the citrus mealybug, *Planococcus citri* (Risso) depends on the different host plant families and the climatic conditions prevailing in different regions of Egypt.

**2. Number of Field Generations:**

The numbers of the cotton mealybug, *P. solenopsis* adults on okra leaves during 2019 and 2020 seasons were used to determine the number of their generations according to Audemard and Milaire (1975). In Egypt, the aforementioned method was used to determine the number of field generations of the pink mealybug of sugar cane, *Saccharicoccus sacchari* (Cockerell) (Hemiptera: Pseudococcidae) (Ebieda *et al.,* 2020). Tabikha and Abdel-Nasser (2015) determined the field annual generations of Tomato Leaf Miner Moth *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). The number of generations is shown in Figure (2). Figure (2, A) revealed the occurrence of three generations during the 2019 season. Adults of the 1st generation were appeared in the field during the period from March, 10 to April, 14. This generation lasted 36 days. The 2nd generation started from April, 21 to June, 2 and lasted 43 days. The 3rd generation was observed from June, 9 to July, 28 and lasted 50 days; whereas Figure (2, B) showed also three generations for *P. solenopsis* during 2020 season.

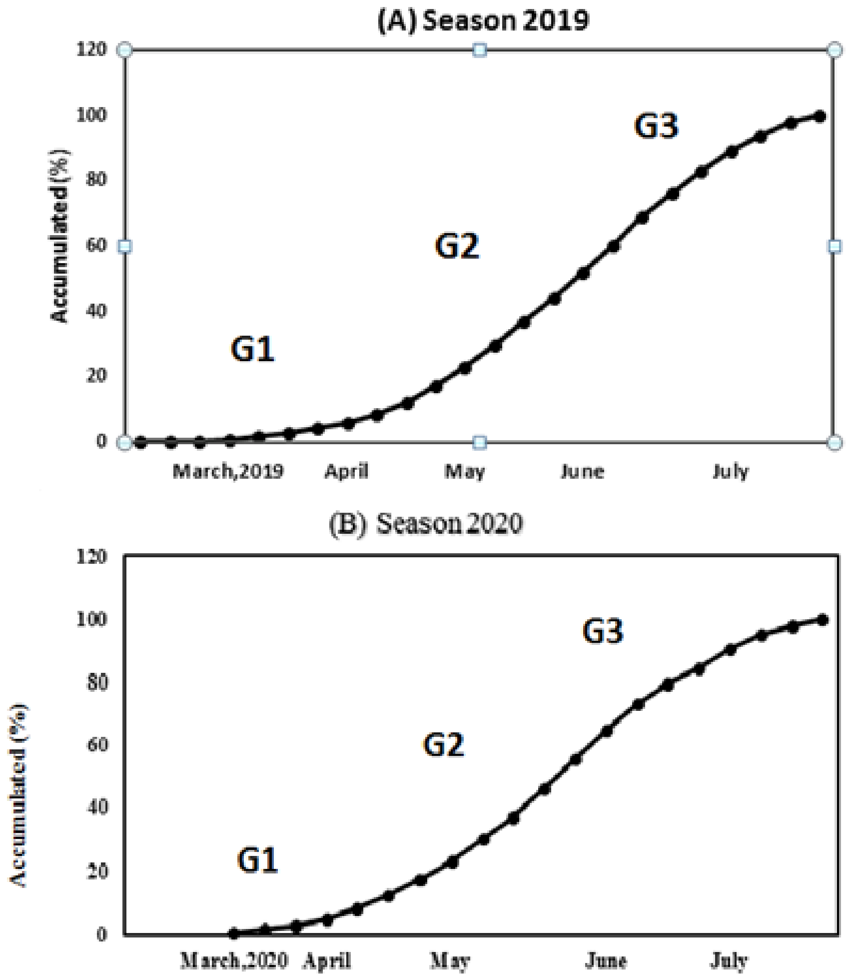



**Fig. 2:** Number of *P. solenopsis* adults field generations, arranged during 2019 and 2020 seasons, at Qena governorate.

The 1st generation was observed from March, 15 to April, 12 and lasted 29 days.

The 2nd generation began from April, 19 to June, 7 and lasted 50 days. The 3rd generation was observed in the field from June, 14 to July, 26 and lasted 43days. Results of both seasons revealed that there are three generations for *P. solenopsis* on okra leaves in the Qena region. The shortest generation was the 1st one where the temperature was at its low levels during the period of this generation. Many authors have obtained the same result in which the cotton mealybug insect has three generations (Abd El-Razzik, 2018; Nabil, 2017). On other hand, Anonymous (2013) in Australia stated that depending on temperature, the cotton mealybug can produce 6-8 generations per year. The discrepancy in the results is due to the different geographical distribution of regions and, consequently, to the different prevailing climatic factors. The difference in the results may also be due to the difference in the host plant and to the different agricultural practices followed.

The distribution of the cotton mealybug was studied on okra leaves surfaces as follow:

Data in Table (4), illustrated the total number of alive stages of *P. solenopsis* was higher on the lower leaf surface (5370 and 8195 individuals) than those on the upper leaf surface (3289 and 5627 individuals) during the 2019and 2020 seasons, respectively. Data confirm that the *P. solenopsis* was negatively phototrophic. The lower leaf surface was in shade and not exposed to the effect of direct sun and consequently was protected from a high temperature.

**Table 4:** Monthly numbers of *P. solenopsis* Tinsley on the upper and lower surface of okra plant leaves at Qena Governorate during 2019 and 2020 Seasons

| Month | 2019 Season | | | | | | 2020 Season | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Upper surface | | | Lower surface | | | Upper surface | | | Lower surface | | |
| | Adult | Nymphs | Total | Adult | Nymphs | Total | Adult | Nymphs | Total | Adult | Nymphs | Total |
| March | 22 | 58 | 80 | 36 | 94 | 130 | 18 | 57 | 75 | 28 | 89 | 117 |
| April | 74 | 236 | 310 | 94 | 563 | 657 | 88 | 416 | 504 | 160 | 642 | 802 |
| May | 134 | 885 | 1019 | 226 | 1460 | 1686 | 214 | 2115 | 2329 | 423 | 3009 | 3432 |
| June | 209 | 1258 | 1467 | 306 | 1972 | 2278 | 207 | 1914 | 2121 | 286 | 2631 | 2917 |
| July | 106 | 307 | 413 | 121 | 498 | 619 | 91 | 507 | 598 | 169 | 758 | 927 |
| **Total** | **545** | **2744** | **3289** | **783** | **4587** | **5370** | **618** | **5009** | **5627** | **1066** | **7129** | **8195** |

Nabil (2017) reported that the population of *P. solenopsis* was higher on the lower leaf surface than those on the upper leaf one. Javadi and Mahdavian (2011) showed that in winter the population of *Icerya purchasi* was higher on exposed sunny trees than that on shady ones, while in spring and summer it was inversed. Ben-Dov (2005) found that *Icerya Seychellarum* females seek out a protected place to lay eggs. This confirms with evidence that the distribution of mealybug on the same plant is related to the age of the plant and the site of infestation and the strength of the plant's structure. The current study helped to understand the distribution behavior of *P. solenopsis* on the two surfaces of okra plant leaves and it also indicates the places that can be found on the cotton mealybugs and this helps in estimating the level of infestation.

**Factors Affecting the Cotton Mealybug Population:**

**1. Weather Elements:**

**1.1. 2019 Season:**

The results in Table 5 showed that the simple correlation coefficient between the effect of temperature (maximum and minimum) and relative humidity on the pest population. The temperature was a positively high significant effect on the pest population, while the effect of humidity was insignificant. The multiple regression analysis showed that the three studied weather factors could be accountable for 87.86% of the changes in *P.*

*solenopsis* population. The efficiency of each element on the pest population changes was 58.28, 29.41, and 0.17 for minimum temperature, relative humidity, and maximum temperature, respectively.

**1.2. 2020 Season:**

Results in Table 5 indicated that the study of the simple correlation between temperatures (maximum and minimum) and relative humidity and pest population gave similar results for the first season. Also, Multiple-regression analysis proved that the effectiveness of the studied weather elements occupied the same arrangement of the first season. It seems that the variation in the action of mortality factors such as weather elements causes considerable population fluctuations. The results of our study agreed with the results of Prasad *et al.* (2012) who demonstrated that the developmental duration of *P. solenopsis* significantly diminished with increasing temperature from 18 to 32 C$^o$. On the contrary, the results of Hamead *et al*. (2014) and El-Zahi and Farag (2017) showed that the relative humidity had the largest effect on the population of *P.solenopsis.*

**Table 5:** Multiple regression analysis between the total number of (*P. solenopsis* and *A. arizonensis* and *N.includens*) and some weather element during 2019 and 2020 Seasons.

| Growing season | Weather element | Insect species | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *P.solenopsis* | | | | | *A. arizonensis* | | | | | *N.includens* | | | | |
| | | r | R | $R^2 \times 100$ | Decrease in $R^2 \times 100$ | Efficient | r | R | $R^2 \times 100$ | Decrease in $R^2 \times 100$ | Efficient | r | R | $R^2 \times 100$ | Decrease in $R^2 \times 100$ | Efficient |
| 2017/2018 | Non | – | 0.73 | 53.38 | – | – | – | 0.97 | 93.45 | – | – | – | 0.88 | 78.03 | – | – |
| | Max.temp.(X1) | 0.37** | 0.73 | 53.33 | 0.08 | 0.17 | 0.74** | 0.97 | 93.26 | 0.19 | 0.49 | 0.54** | 0.87 | 77.83 | 0.2 | 0.36 |
| | Min.temp.(X2) | 0.67** | 0.52 | 27.22 | 14.5 | 58.28 | 0.93** | 0.79 | 63.11 | 30.34 | 79.7 | 0.77** | 0.69 | 48.37 | 29.66 | 53.91 |
| | Avg.R.H.%(X3) | 0.18** | 0.78 | 61.45 | 9.14 | 29.41 | 0.41** | 0.94 | 88.4 | 5.05 | 13.3 | 0.18 | 0.82 | 64.95 | 13.08 | 23.77 |
| 2018 /2019 | Non | – | 0.81 | 65.84 | – | – | – | 0.92 | 84.31 | – | – | – | 0.91 | 82.39 | – | – |
| | Min.temp.(X2) | 0.5** | 0,80 | 64.02 | 0.64 | 1.94 | 0.64** | 0.91 | 83.6 | 0.71 | 1.56 | 0.61** | 0.91 | 82.1 | 0.29 | 1.7 |
| | Min.temp.(X2) | 0.77** | 0.63 | 39.87 | 14.86 | 45.27 | 0.89** | 0.68 | 46.68 | 37.63 | 71.9 | 0.86** | 0.74 | 53.88 | 28.51 | 68.71 |
| | Avg.R.H.%(X3) | 0.28** | 0.74 | 54.92 | 11.61 | 33.47 | 0.41** | 0.92 | 83.93 | 0.38 | 10.8 | 0.30** | 0.88 | 77 | 5.39 | 12.98 |

**2.** ***Aenasius arizonensis*** **(Girault) (Hymenoptera: Encyrtidae) parasitoid:**

**2.1. Survey, Seasonal Abundance, Percentages of Parasitism and Effect of Weather Elements:**

**2.1.1. 2019 Season:**

The results of the research during this season showed that one species of the parasitoid was recorded on the cotton mealybug, and it was defined as, *Aenasius arizonensis.*

Results of Table 1 referred that the number of parasitized *P. solenopsis* adults (the emerged *A. arizonensis* number) started with 9 individuals/30 leaves on 31 March. The number of the individual population gradually increased, reaching its maximum during the fourth week of June (68 insects/30leaves). After that, the population then decreased gradually in a fluctuated manner to reach its lowest number during the last week of July (6 insects/30 leaves each). The percentages of parasitism, during this season, ranged from 4.29 to 12.31%. The lowest percentage was recorded during March and the highest one during April (Table 1).

Data in Table 5 show the multiple-regression analysis between the population density of *A. arizonensis* towards the maximum, minimum temperature and relative humidity. The multiple regression analysis proved that the three weather factor variables studied were responsible for about (93.44%) of the changes in the population of *A.*

*arizonensis*. Most of these changes (79.68%) were due to the effect of minimum temperature followed by (13.28%) and (0.49%) for the effects of relative humidity and maximum temperature.

**2.1.2. 2020 Season:**

Results of surveying parasitoids during the second season revealed that no parasitoid was found more than that during the first one.

Data of Table 2 showed that the parasitoid population (parasitized pest adults) started with a low number of 3 individuals/30 leaves during the 2nd week of march, subsequently, the number of parasitoids began to increase gradually in a fluctuating way, until it reached the highest number during the first week of June (94 individuals / 30 leaves were recorded). After that, the number decreased gradually till it reached its lowest level of abundance, 18 individuals/30leaves, during the last week of July.

Also, data presented in Table 2 showed that the percentage rate of parasitism extended from (5.80% –10.57%) during June to April. The data in Table 5 showed that the simple correlation analysis demonstrated that the effect of the three weather elements on parasitoid counts during this season was similar to the first season. The multiple regression analysis detected that the three thoughtful variables were accountable for (84.33%) of the alterations in *A. arizonensis* counts. The minimum temperature was primarily responsible for most of the changes (71.94%) followed by (10.83%) and (1.56%) for the effects of relative humidity and maximum temperature.

Data of both seasons regarding the population dynamic of *A. arizonensis*, that the number of this type of parasitoid was clearly synchronized with the pest population. Also, data of both seasons, concerning the low parasitism percentages, similar parasitism percentages were observed by many authors arrived at the same results. Tanwar *et al.* (2008) recorded from 20 to 70% parasitization of *P. solenopsis* by *A. arizonensis*, Mohindru *et al*. (2009) reported from 10 to 45% parasitism in *P.* solenopsis by the same parasitoid *A. arizonensis* in India and In Sudan Mohamed *et al.* (2019) proved that the population of *A. arizonensis* was low with an average parasitism rate of 31.26% during the two years of the study when studied on several host plants. From the viewpoint of the researcher, the lack of parasitism rates is attributed to, this parasitoid species may not have existed yet in the Qena region or this may be also due to the application of insecticides in neighboring agricultural crops for the management of sucking pests like jassids, whitefly, and mealybug. Though this parasitoid has an excellent searching ability, isolated and scattered mealybugs were also effectively parasitized and can also be reared easily in the laboratory. These characteristics make it an ideal parasitoid for exploitation in the biological control of *P. solenopsis* mealybug. Therefore, there is a need to develop some strategies to preserve this natural enemy.

**3. *Nephus includens (Kirsch)* (Coleoptera: Coccinellidae) Predator:**

**3.1. Survey, Seasonal Abundance, Percentages of Predation and Effect of Weather Elements:**

During the two seasons of the study, one type of predator, *N. includes* were monitored. It is worth noting that the results indicated that only a part of the number of insects was recorded as preyed and not the total number. This is due to the fact that numbers of preyed on moving individuals are difficult to estimate especially in the early stages of cotton mealybug nymphs, which are characterized by their speed of movement.

**3.1.1. Season 2019:**

Throughout the study season, the predator's numbers were recorded simultaneously with the number of its prey, *P. solenopsis*, and both of them are affected by the temperature prevailing in the area. As shown in the results of Table 1, the predator numbers began with (6 individuals / 30leaves) in March, then the numbers gradually increased until they reached the highest number (22individuals / 30 leaves) in the 1st week of June. After that, the predator population began to gradually decrease during June, until the number reached its lowest level (8 individual / 30 leaves) during July. The percentages of predates, during this season, ranged from 2.35 to 4.55%. The lowest percentage was recorded during June and the highest one during April (Table 1).

**3.1.2. Season 2020:**

Table 2 showed that the number of *N. includens* began with (3individuals / 30 leaves) in April, then the numbers increased gradually until it reached the highest number of (61 individuals/30 leaves) in June. After that, the predator numbers decreased during June, until reached their lowest level (9 individual/30 leaves) during July. The percentages of predates, during this season, ranged from 2.60 to 3.87%. The lowest percentage was recorded during April and the highest one during July. Confirming previous results, data presented in Table 5 show that both seasons revealed that the minimum temperature factor (53.91 and 68.71) was responsible for the most changes in the predator, *N. includens* population followed by (23.77 and 12.98) and (0.36 and 1.70) for the effects of relative humidity and maximum temperature during the 1st and the 2nd year, respectively. In India, registered this species of predator *N. includens* feeding on *P. solenopsis* not only on the cotton plant but on other economic crops Fand *et al*. (2010). Sreedevi *et al*. (2013) found that the minimum temperature was responsible for the most changes in the predator, *N. includens* population.

The data in Table 6 demonstrated that the simple correlation coefficient between the parasitoid *A. arizonensis* (x1) and the pest population was highly significant, ranging between 68.25 and 77.53% during the 2019 and 2020 seasons respectively

In the case of the effect of the predator *N. includens* (x2) on the population of the pest is less than the effect of the parasite, but with a highly significant ranging between 27.64 and 31.25% during both seasons of study.

**Table 6:** Multiple regression analysis between the total number of the *P.solenopsis* and *A arizonensis* and *N. includens* during 2019 and 2020 seasons

| season | Natural enemies | r | R | $R^2$ ×100 | Decrease in R2 ×100 | Efficiency |
|---|---|---|---|---|---|---|
| 2019 | Non | – | 0.7125 | 50.77 | – | – |
| | *Aenasius arizonensis*(X1) | 0.5831** | 0.5621 | 31.6 | 23.18 | 68.24 |
| | *Nephus includens*(X2) | 0.5614** | 0.6731 | 45.31 | 4.16 | 27.64 |
| 2020 | Non | – | 0.6172 | 38.09 | – | – |
| | *Aenasius arizonensis*(X1) | 0.5721** | 0.6011 | 36.13 | 17.24 | 77.53 |
| | *Nephus includens*(X2) | 0.5235** | 0.6416 | 41.17 | 3.28 | 31.25 |

Angel *et al*. (2017) proved that parasitoid; *A. arizonensis* was the most important factor in reducing the number of *P. solenopsis* in comparison to the types of parasitoids that can be present with it on the same pest**.**

**4-Biological Parameters of Female *P. solenopsis* (Tinsley) on Sprouted Potato Under Laboratory Conditions:**

The importance of studying the biology of this pest is due to the understanding and awareness of the shape and extent of its population growth. Since, the difficulty of studying the life history and pattern of biological activities of *P. solenopsis* under field conditions due to the overlap of biotic and abiotic factors, so such laboratory studies should be conducted.

Through our study, the results of the biological study proved that the female *P.*

*solenopsis* has three instars of nymphs and the adult stage (not wingless). The results in Table 7 indicated that the adult female *P. solenopsis* had a pre-oviposition, oviposition and post oviposition period of 8.22 ± 0.32, 15.75 ± 0.85 and 4.17 ± 0.52 days, respectively. The female formed 4.32±0.62 ovisacs during its life span in which around 618.81 ± 103.31 eggs were deposited that hatched within few minutes (10.75 ± 0.75 minutes). The high fecundity rate of *P. solenopsis* showed its higher survival rate. The developmental period for the first, second and third nymphal instar was 5.38±0.72, 6.18±0.85 and 7.38±0.76 days respectively. The adult female lived longer (27.23 ± 2.35 days). The total life duration of females was (47.05 ± 3.17 days).

**Table 7:** Biological parameters of *P. Solenopsis* (Tinsley) on sprouted potato under laboratory conditions

| Biological Parameters | Mean | Range |
|---|---|---|
| Incubation period (minutes) | 10.75 ± 0.57 | 9.81 – 7.16 |
| First nymphal instar | 5.38 ± 0.72 | 4 – 7 |
| Second nymphal instar | 6.18 ± 0.85 | 5 – 8 |
| Third nymphal instar | 7.38 ± 0.76 | 6 – 9 |
| Pre-oviposition period (days) | 8.22 ± 0.32 | 7 – 10 |
| Oviposition period (days) | 15.75 ± 0.85 | 14 – 16 |
| Post-oviposition period (days) | 4.17 ± 0.52 | 3 – 5 |
| Fecundity (no. of eggs laid/ female) | 618.81 ± 103.31 | 310 – 650 |
| Ovisacs (no. of ovisacs/ female) | 4.32 ± 0.62 | 3 – 6 |
| Adult longevity (days) | 27.23 ± 2.35 | 25 – 30 |
| Total life cycle (days) | 47.05 ± 3.17 | 39 – 55 |

Similarly, studies on the biology of mealybug *P. solenopsis* under laboratory conditions on potato sprouts found that the total life span was 43-53 days in the case of female (Anitha,2021). In India, studies the biology of *P. solenopsis* in Laboratory on twigs of cotton plants Vennila *et al.* (2010). It was found that the longevity of female was 42.4 ±5.7days under conditions of temperature and relative humidity ranging from 25 to 30 ˚C and 75 to 80%, respectively. Biological studies of other mealybug species of the same family such as *Planococcus citri* (RISSO) showed that the total life cycle life of females was 41.8 ± 0.58 days when they were cultured in the laboratory on the shoots of potato plants at a temperature of 25 ± 1˚C. Relative humidity 65 ± 5% Mohamed *et al*. (2017). Conducting such biological studies on *P. solenopsis* provides us with a lot of information about the adult life span, which is characterized by its large size and dense wax cover, and this is useful in estimating the nutritional needs of that pest and predicting the times of its appearance, symptoms and losses that may befall the crop, and consequently, such a study Biology indirectly helps in selecting and estimating methods of controlling this pest in the field.

## Conclusion

*P. solenopsis* Tinsley was recorded for the first time on the okra plant at Qena Governorate, Egypt, and its population changes from one season to another. The current study provides us with some important information regarding the ecology and biology *of P. solenopsis*, which was detected as a new pest in the Qena Governorate. At present, the cotton mealybug bug is considered a new pest on okra plants, but it is considered one of the dangerous pests that can be transmitted and infect other important economic crops. The results of the study showed the activity of cotton mealybug throughout the two study seasons and their registration for several overlapping generations. The predator, *N.*

*includens* was not able to significantly reduce the pest population. However, the effect of the parasitoid, *A. arizonensis* on the pest population was higher than that of the predator. The study highlighted the climatic changes which had a great impact on the population dynamics of cotton mealybug and its natural enemies. On the other hand, the biological study of *P. solenopsis* has important information that helps us to understand well its method and degree of population growth. Based on the above, the results obtained from the previous study will contribute to building and developing a successful integrated pest management (IPM) program for *P. solenopsis*, which is one of the main and polyphagous pests in Egypt and the world.

## REFERENCES


Abdel-Razzik, M. I. (2018). Seasonal fluctuation of the cotton mealybug, *Phenacoccus solenopsis* (Hemiptera: Pseudococcidae) and its natural enemies on mulberry trees in Egypt. *Egyptian journal of plant protection research institute,*1 (1): 74-83.

Abdel-Salam, A. H.; Ghanim, A. A. and Awadalla, H. S. (2010). Biological attributes and life table parameters of *Nephus includens* (Kirsch) (Coleoptera: Coccinellidae) as a natural enemy of margarodid mealybugs.*Journal of plant protection and pathology,* 1: 51-62.

Abd-Rabou,S.; Germain, J.F. and Malausa, T. (2010). *Phenacoccus parvus* Morrison and *Phenacoccus solenopsis* Tinsley, two new scale insects in Egypt (Hemiptera: Pseudococcidae). *Bulletin Societie Entomogique France,* 115(4):509-510

Abdul- rassoul, M. S. (2018). First record of *Aenasius arizonensis* (Girault, 1915) (Hymenoptera, Encritidae), A parasitoid of *Phenacoccus solenopsis* Tinsley, 1898 (Hemiptera, Pseudococcidae) in Iraq. *Bulletin Iraq Natural History Museum,* 15(1): 93-100.

Ahmed, H. N. and Adb-Rabou S. M. (2010). Host plant, geographical distribution, natural enemies and biological studies of the citrus mealybug, *Planococcus citri* (Risso) (Hemiptera: Pseudococcidae). *Egyptian Academic Journal of Biological Sciences, (A.Entomology ),* Vol.3 (1): 39-47.

Ahmed, M. Z.; Ma, J.; Qiu, B.L.; He, R.R.; Wu, M.T.; Liang, F.; Zhao, J.P.; Lin, L.; Hu, X.N.; Lv, L. H.; Breinholt, J.W. and Lu,Y.Y. (2015). Genetic record for a recent invasion of *Phenacoccus solenopsis* (Hemiptera: Pseudococcidae).*Asia. Environmental Entomology,* 44(3):907-918

Angel, R. A.; Kamal, T. A. and John, N. (2017). First Record of *Aenasius arizonensis* (Hymenoptera: Encyrtidae) as A solitary, Endoparasitoid of Cotton Mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) Infesting Different Host Plants at Giza Region in Egypt. Egypt. *Egyptian Academic Journal of Biological Sciences, (A.Entomology ),* 10(7): 127–134.

Anitha, G. (2021). Biology and life cycle of cotton mealy bug, *Phenacoccus solenopsis* on potato sprouts. *Journal of Entomology and Zoology Studies*, 9(1): 756-759.

Anonymous (2013). Solenopsis mealybug in Australia – an overview. State of Queensland, Department of Agriculture, Fisheries and Forestry, 1-2.

Audemard, H. and Milaire, H.G. (1975). Le piégeage du Carpocapse (Laspeyresia pomonella L.) avec une phéromone sexuelle de synthése. Premiers résultants utilisables pour 1éstimation des populations et al conduite de la lutte. *Annales de Zoologie Ecologie Animale,* 7(1):61-80.

Babasaheb, B.F. and Suroshe, S.S. (2015). The invasive mealybug, *Phenacoccus solenopsis* Tinsely, a threat to tropical and subtropical agricultural and horticultural production systems- A review. *Crop Protection,* 69: 34-43.

Ben-Dov,Y. (2005). A systematic catalogue of the scale insect family Margarodidae (Hemiptera: Coccoidea) of the world. Intercept Limited, Wimborne,UK 400 pp.

Clark, A. (2003). Costs and consequences of evolutionary temperature adaptation.*Trends in Ecology and Evolution,* 18: 327-334.

Costa, K. D.; Silva, J. D.; Santos, A. M.; Filho, J. I.; Santos, P. R. and Noscomente, M. R. (2018). Breeding Methods to Obtain Superior Genotypes of Okra. *American Journal of Experimental Agriculture International,* 21(1): 1- 6.

Ebieda, A. M.M.; Mohanny, K.M.; Ghada, S. M.; Allam, R.O.H. and Marwa, A.A. S.(2020). Predicted voltinism for *Saccharicoccus sacchari* (cockerell) (Hemiptera: pseudococcidae) on sugarcane in Egypt. *Plant Archives,* 20(2): 2708-2714.

Elbahrawy, A.M.S.U.H.; Hammad, K.A.A.; Ahmed, E.A.M.E. and Shaban A. (2020). Seasonal incidence of the cotton mealybug, *Phenacoccus solenopsis* tinsley (Homoptera: pseudococcidae) infesting tomato in correlation with certain biotic and abiotic factors. *Plant Archives,* 20(1): 483-492.

El-Zahi, S.E. and Farag, A.I. (2017). Population dynamic of *Phenacoccus solenopsis* Tinsley on cotton plants and its susceptibility to some insecticides in relation to the exposure method. *Alexandria Science Exchange Journal*, 38(2)231-237.

El-Zahi,S.E.; Aref, S.A. and Korish, S.K.M. (2016). The cotton mealybug, *Phenacoccus solenopsis* Tinsly (Hemiptera: Pseudoccidae) as anew menace to cotton in Egypt and its chemical control. *Journal of Plant Protection Research,* 56(2):111-115

Fallahzadeh, M.; Japoshvili, G.; Abdimaleki, R. and Saghaei, N. (2014). New records of Tetracneminae (Hymenoptera, Chalcidoidea, Encyrtidae) from Iran. *Turkish Journal of Zoology,* (38): 515- 518.

Fandi, B.B; Gautam, R. D. and Suroshe, S.S. (2010). Comparative biology of four coccinellid predators of solenopsis mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae). *Journal of Biological Control,* 24 (1): 35–41.

Fisher, T.W. (1963). Mass culture of Cryptolaemus and Leptomastix: natural enemies of the citrus mealybug. California Agricultural experiment station, Berkeley, USA, No 797, 38pp.

Gemede, H. F.; Ratta, N.; Haki, G. D.; Woldegiorgis, A. Z. and Beyene, F. (2015). Nutritional quality and health benefits of “Okra” (*Abelmoschus esculentus*): A review. *International Journal of Nutrition and Food Sciences,* 4(2): 208-215.

Hameed, A.; Shahzad, M.S.; Mehmood, A.; Ahmad, S. and Islam, N. (2014). Forecasting and modeling of sucking insect complex of cotton under agro-ecosystem of Multan-Ppunjab, Pakistan. *Pakistan Journal of Agricultural Sciences,* 51(4):99-103.

Ibrahim,S.S.; Moharumand, F.A. and Abd El-Ghany, N.M. (2015). The cotton mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) as a new insect pest on tomato plants in Egypt. *Journal of Plant Protection Research*, 55(1):48-51.

Izhevsky, S.S. and Orlinsky, A.D. (1998). Effect of temperature on development and reproduction of a predatory beetle, *Nephus includens* Kirsch (Coleopetra: Coccinellidae). *Entomophaga,* 33(1): 101-114.

Javadi,S. and Mahdavian,S.E.(2011). Biology,seasonal population fluctuation and distribution of the cottony cushion scale *Icerya purchasi* Maskell (Hom: Margarodidae) in east of Mazandaran province, Iran. *Journal of Entomological Research,* 5(3): 209-217.

Kontodimas, D.C.; Eliopoulos, P. A.; Satathas, G.T. and Economou, L.P. (2004). Comparative temperature-dependent development of *Nephus includens* (Kirsch) and *Nephus bisigantus* (Bohiman) (Coleopetra: Coccinellidae) preying on *Planococcus citri* (Risso) (Homopetra: Pseudococcidae): evaluation of a linear and various nonlinear models using specific criteria. *Environmental Entomolgy,* 33(2):1-11.

Kontodimas, D.C.; Milonas, P.G.; Stathas, G.J.; Economou, L.P. and Kavallieratos, N.G. (2007). Life table parameters of the pseudococcid predators *Nephus includens* and *Nephus bisigantus* (Coleopetra: Coccinellidae). *European Journal of Entomology,*104: 407-415.

Mohamed, A. N.; Awad, K. T. and Abubaker, H.M. A. (2019). Effectiveness of Endoparsitoid Wasp *Aenasius Arizonensis* (Girault) as a Successful Bio-Control of Cotton Mealy Bug, *Phenacoccus Solenopsis* Tinsley, in Khartoum State, Suda. Journal of Agronomy Research 2(1):22-28.

Mohamed, T. H.; Nabil, H. A.; Shahein, A. A .and Mohamed, Z.A. (2017). Biological studies on the citrus mealybug, *planococcus citri* (RISSO) (Hemiptera: Pseudococcidae) under laboratory conditions. *Zagazig Journal of Agricultural Research,* 44 (3):1097-1106.

Mohindru, B.; Jindal, V. and Dhawan, A. K. (2009). Record of parasitoid on mealy bug *Phenacoccus solenopsis* in tomato. *Indian Journal of Ecology,* 36(1): 101–2.

Nabil, H.A. (2017). Ecological studies on cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Sternorrhyncha: Coccoidea: Pseudococcidae) on eggplant at Sharkia Governorate, Egypt. *Egyptian Academic Journal of Biological Sciences, (A.Entomology ),* 10 (7): 195–206.

Prasad, Y.G.; Prabhakar, M.; Sreedevi, G.; R.Rao, G. and enkateswarlu, B.V. (2012). Effect of temperature on development, survival and reproducing of the mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) on cotton. *Crop Protection,* 3(9):81-88.

Priya, S.; Chauhan, V.; tiwari, B. K.; Chauhan, S. S.; Simon, S.; Bilal, S. and Abidi, A. B. (2014). An overview on okra (*Abelmoschus esculentus*) and its importance as a nutritive vegetable in the world. *Ijpbs* vol. 4(2), apr- jun: 227-233.

Sahito, H.A.; Abro G.H.; Mahmood, R. and Malik, A.Q. (2011). Survey of mealybug, *Phenacoccus solenopsis* (Tinsley) and effect of bio-ecological factors on its population in different ecological zones of Sindh. *Pakistan Journal of Agriculture, Agricultural Engineering and Veterinary Sciences,* 27 (1): 51-65.

Shah, T.N.; Ahmed, A.M. and Memon, N. (2015). Population dynamics of cotton mealybug, *Phenacoccus solepnosis* Tinsely in three taluses of district Sanghar (Sindh). *Journal of Entomology and Zoology Studies,* 3(5): 162-167.

Shahid, M.R.; Farooq, J.; Mahmood, A.; Ilahi, F.; Riaz, M.; Shakeel, A.; Petrescu- Mag, I.V. and Farooq, A. (2012). Seasonal occurrence of sucking insect pest in cotton ecosystem of Punjab, Pakistan. *Advances in Agriculture & Botanics*, 4 (1): 26-30.

Shahzad, M.Q.; Abdin, Z. U.; Abbas, S. K. and Tahir, M. (2016). Parasitic effects of solitary endoparasitoid, *Aenasius bambawalei* Hayat (Hymenoptera: Encyrtidae) on Cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae). *Advance Entomology,* (4): 90-96.

Solangi, G.S.and Mahmood, R. (2011). Biology, host specificity and population trends of *Aenasius bambawalei* Hayat and its role controlling mealybug *Phenacoccus solenopsis* Tinsley a Tandojam Sindh. CABI South Asia, Tando Jam Pakistan.

Sreedevi, G.; Prasad, Y.G.; Prabhakar, M.; Rao, G.R.; Vennila, S. and Venkateswarlu, B. (2013). Bioclimatic thresholds, thermal constant and survival of mealybug, *Phenacoccus solenopsis* (Hemiptera: Pseudococcidae) in response to constant temperatures on Hibiscus. *Plos one,* 8 (9): 1–14.

Tabikha, R. M. M. and Abdel-Nasser, T. H. (2015). Annual Generations and Population Fluctuation of Tomato Leaf Miner Moth *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in El-Behera Governorate, Egypt. Egypt. *Egyptian Academic Journal of Biological Sciences, (A.Entomology ),* 8(1): 141-153.

Tanwar, R. K.; Bhamare, V. K.; Ramamurthy, V. V.; Hayat, M.; Jeyakumar,P.; Singh, A. and Bambawale, O. M.( 2008). Record of new parasitoids on mealy bug, *Phenacoccus solenopsis*. *Indian Journal of Entomology*, 70(4): 404–5.

Van Driesche, R.G. (1983). Meaning of "Percent Parasitism"in studies of Insect Parasitoids. *Environmental Entomology,*12: 1611 – 1622.

Vennila, S.; Deshmukh, A.J.; Pinjarkar, D.; Agarwal, M.; Ramamurthy, V.V.; Joshi, S.; Kranthi, K.R. and Bambawale, O.M. (2010). Biology of the mealybug, *Phenacoccus solenopsis* on cotton in the laboratory. *Journal of Insect Science,* 10:115 -119.

## ARABIC SUMMARY

**دراسات على ديناميكية تعداد وبيولوجيا بق القطن الدقيقى واعدائه الحيوية كحشرة جديدة على نبات البامية في محافظة قنا - مصر.**

**غادة صلاح محمد**
قسم وقاية النباتات -كلية الزراعة – جامعة جنوب الوادى – قنا

يعد بق القطن الدقيقي أحد أهم الآفات الحشرية التي تصيب العديد من المحاصيل الاقتصادية الهامة في جميع أنحاء العالم. سجلت الحشرة لأول مرة على نباتات البامية بداية شهر مارس خلال موسم 2019 بمزرعة كلية الزراعة جامعة جنوب الوادى بقنا.

أظهرت نتائج كلا الموسمين وجود أعلى تعداد أسبوعي من بق القطن الدقيقى خلال الأسبوع الأول من شهر يونيو. كما تظهر النتائج ان أعلى نسبة مئوية من التعداد الكلى االموسمى في شهر يوليو (37,87، 39,56٪) خلال الموسمين الأول والثاني على التوالي. بالإضافة إلى ذلك، وجد ان لهذه الحشرة ثلاثة أجيال في الموسم تحت الظروف الحقلية.

وقد تم دراسة تأثير العوامل الحيوية وغير الحيوية على تعداد هذه الآفة. كما تم تصنيف نوع واحد من الطفيليات وهو *Aenasius arizonensis (*Girault) وقد بلغت أعلى نسبة للتطفل 12,31٪ خلال الموسم الأول من الدراسة. كما سجل لحشرة بق القطن الدقيقى خلال موسمى الدراسة مفترس واحد هو *Nephus includens* (Kirsch) وكانت أعلى نسبة للإفتراس 4,55٪ . كما أمكن ايضا دراسة تأثير العوامل الجوية على تعداد هذه الحشرة.

أجريت الدراسات البيولوجية لحشرة بق القطن الدقيقى في ظروف مختبريه على البراعم المنبثقة لنباتات البطاطس. و قد سجلت نتائج الدراسات البيولوجيه أن معدل خصوبة الإناث تراوح بين (310 إلى 650 بيضه / انثى) مما يزيد من معدل البقاء على قيد الحياة، بلغ طول عمر االإناث حوالى (27.2±2.35 يوم) وتراوحت مده دورة الحياة الكلية من 39-55 يوم.

وفقًا لذلك، يمكن إستخدام المعلومات التي تم الحصول عليها من هذه الدراسة فى إختيار الوسائل المناسبة للتحكم فى إدارة تلك الآفه من خلال فترات النشاط والتكاثر.