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Article

Effects of natural enemies on *Phenacoccus solenopsis* Tinsley population on Maize plants in Kafr El-Sheikh Governorate, Egypt

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Abstract: In Egypt, maize (*Zea mays* L.) is one of the most important cereal crops. *Phenacoccus solenopsis* Tinsley is a significant insect pest that infests economically significant plants, with its population dynamics closely linked to its natural enemies' activities. In order to investigate the cotton mealybug *P. solenopsis* population fluctuations, and the effect of some ecological factors on it experiments were carried out on a maize field in Sidi Salem District, Kafr El-Sheikh Governorate, Egypt, for two consecutive seasons, 2021and 2022. *P. solenopsis* population density nymph and adult were highest on July 24th with 312 nymphs and 71 adults, and highest on 25th and 15th July and with 406 nymphs and 92 adults, respectively. During the first and second season, the highest peak of the parasitiod *A. arizonensis* was on 24th of July (33 and 49 individuals / sample). There is high significant correlation between the nymph of *P. solenopsis* and *A. arizonensis* in both season of the study. During this study there were three predators (*Chrysoperla carnea*, *Scymnus* sp. And *C. undecimpunctata*) associated with *P. solenopsis*. According to statistical analysis, there is a significant relationship between *P. solenopsis* nymphs and adults and *Scymnus sp*. in both seasons. When compared to natural enemies, multi-regression analysis revealed that the combined impact of meteorological conditions had a less effect on *P. solenopsis* nymph and adult stages. Also, multi regression shows the combined impact of both biotic and abiotic elements on the nymph and adult stages of *P. solenopsis* reached 94.66 and 78.99 during the first season and reached 94.28 and 84.00% during the second season.

Key words: Maize, *Phenacoccus solenopsis*, parasitoids, predators, weather factors.

1. Introduction

One of the most important cereal crops in Egypt and other nations is maize (*Zea mays* L.), which comes in third place behind rice and wheat. Since it is ingested by both people and cattle, maize is an annual plant that is essential to global food security. With an average output of 8154.48 tones/ha, Egypt's total cultivated area of maize in 2020 was 871076.12 hectares (1 hectare = 10,000 m^2). In 2020, **El-Rasoul *et al*. (2020).** Many damaging insect pest species are attacking maize plants at different stages of growth. Many economically significant plants are attacked by the dangerous insect pest known as the cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae), such as eggplants and okra plants, then recorded in large numbers at different stages of growth, which affected the quantity and quality of the crop **(Ismael *et al.* (2024)**. The presence of *P. solenopsis* can also facilitate the spread of pathogens, compounding the negative effects on crop quality **(Shahide *et al.* 2012).**

Controlling cotton mealybugs with chemical pesticides is difficult because the body has a covering of wax on it and their high reproductive capacity, as well as the harmful effect of pesticides on the non-target environment. Therefore, biological control of this pest was important and the income of farmers around the world. This pest has spread rapidly in many countries through the trade of plant crops (**Ismael *et al.*, 2023**). The population dynamics of *P. solenopsis* are closely linked to the activity of its natural enemies. For instance, the introduction of the parasitoid *Aenasius bambawalei* led to a significant reduction in mealybug populations, demonstrating the importance of biological control agents **(Rishikumar *et al.*, 2009).** *A. arizonensis* was recorded associated with *P. solenopsis* in Egypt **(Drder *et al*., 2024)** and India **(Shera *et al*., 2017)**.

The presence of *C. carnea* can significantly reduce mealybug populations such as *P. solenopsis*, thereby enhancing crop health and yield, as seen in cotton fields where mealybug infestations were controlled effectively **(Ram & Saini, 2010 and Rashid *et al*., 2012).** Effective predation by *C. undecimpunctata* on *P. solenopsis* can lead to lower pest incidences, thereby improving crop yields and contributing to food security. For instance, the presence of natural enemies like *C. undecimpunctata* can reduce pest populations significantly, as observed in cotton fields **(Ram & Saini, 2010)** reported that the presence of *Scymnus* sp. enhances the efficiency of natural pest control techniques, especially when used to integrated pest management (IPM) systems. *Scymnus coccivora* is identified as a prominent predator of *P. solenopsis,* contributing to the biological control of this pest **(Arif *et al*., 2011). Drder *et al.* (2024)** reported that *P. Solenopsis* was shown to be connected with the three coccinellid predators, *Hyperaspis vinciguerrae*, *Scymnus syriacus*, and *Nephus hiekei* at Qena governorate

This study was conducted to investigate the population fluctuations of the cotton mealybug *P. solenopsis* and its associated natural enemies in maize field. Also, the effects of natural enemies and certain weather factors on *P. solenopsis* population were statistically estimated.

2. Materials and Methods

2.1. Population fluctuations of the cotton mealybug *P. solenopsis*

Filed experiments were conducted in the field of maize located at Sidi Salem District, Kafr El-Sheikh Governorate, Egypt. The study was extended from May to September for two successive seasons in 2021and 2022. For maize, the investigation was carried out in an area of around one feddan. Set up with four duplicates in a randomized full block design. On May 1st, the plot was planted with 324 hybrid maize varieties for both seasons. The Kafr El-Sheikh governorate's Sakha Agricultural Research Station supplied the cultivar. Normal agricultural methods were used in the field, and no chemical control was used. After 28 days of cultivation, every week, samples (25 infested leaves) were taken from ten randomly selected plants with similar size, shape, and height from all directions. The samples were placed in polyethylene bags and brought into the laboratory for particular examination. These samples were inspected under stereo- microscope at same day, and *P. solenopsis* stages (nymphs and adult females) were counted and recorded. Predators were visually inspected on plants every week. Where, every predator species (as adults) was counted separately and recorded. Also, the collected predators associated with *P. solenopsis* in each sample as immature stages were identified counted for each species.

2.2. Population fluctuation of parasitoids

After counting of nymphs and adult females of *P. solenopsis*, all the collected individuals were maintained in petri- dishes (provided with filter papers) till the emergence of parasitoids which parasitized on *P. solenopsis* stages. The emerged parasitoids were classified, counted and recorded. The parasitoids were identified in Plant Protection Research Institute.

2.3. Effects of some weather factors on the insect populations

Over the course of the investigation, the Central Laboratory for Agricultural reported the experimental region's maximum and minimum air temperatures (°C) as well as the relative humidity percentage (RH%). To estimate the averages of these meteorological parameters, the obtained dates were grouped based on sampling dates.

2.4. Statistical analysis

The COSTAT computer program (2005) was used to calculate the values of simple correlation. In addition, simple and multi regression analysis were done.

3. Results and Discussion

3.1. Population fluctuations of the cotton mealybug *Phenacoccus solenopsis* on maize

During the summer of 2021 and 2022, population fluctuations of the cotton mealybug on maize were evaluated (Figures 1 A and B). Samples for this experiment were gathered between May 29th and September 11th. Data illustrated in figure (1) indicated that the population density of *P. solenopsis* nymphs and adults showed that the highest peak of nymph was recorded on 24th of July and represented by 31.2 nymphs, while, the highest peak of adult was recorded on 17th July with values 71 adult. The second peak of population number of nymph and adult was recorded on 4th of September with values 132 and 36 individuals, respectively during the first season. In the second season, the highest peak of nymph was recorded on 24th of July and represented by 406 nymphs while the highest peak of adult was recorded on 17th July with values 92 adult. Also, second peak of population number of nymph and adult was recorded on 28th of August and 4th of September with values 121 and 47 individuals, respectively.

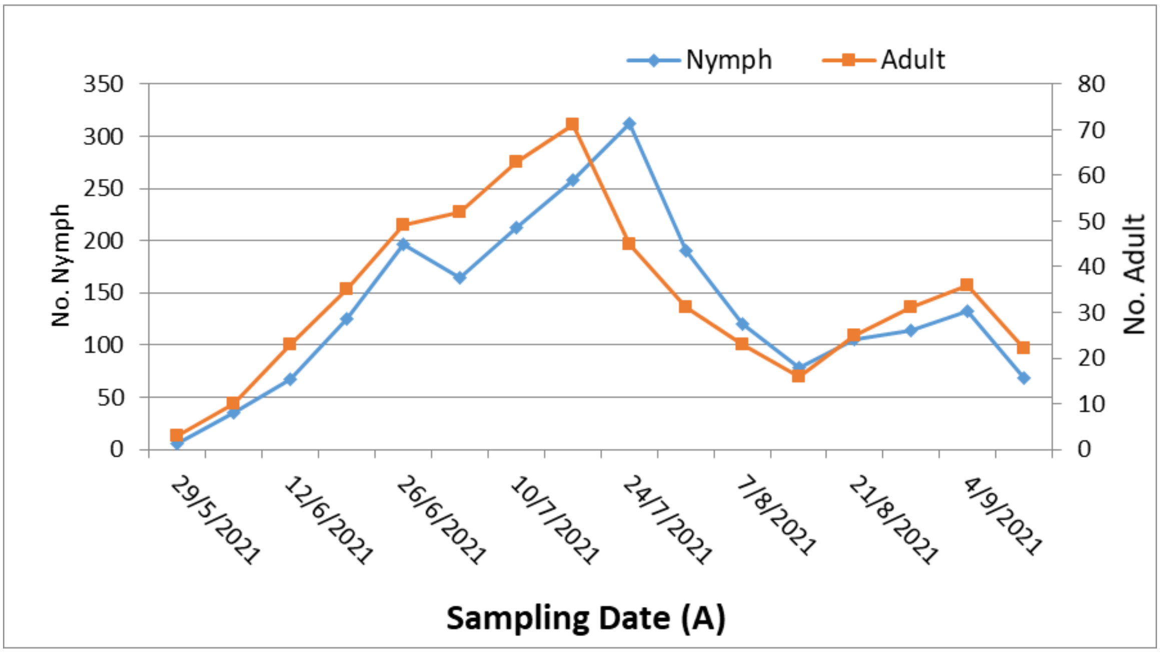
The current findings are similar to those of **Abd El-Mageed *et al*. (2020)**, who found that during two recurrent growing seasons, the summers of 2019 and 2020, there were three annual population fluctuations of the cotton mealybug, *P. solenopsis*, in two types of maize plantations (white sugar corn and yellow singular hybrid 168) in Albalina, Sohag Governorate, Egypt. The host plant variety and/or variations in environmental conditions may be the cause of the variances between the current study and the others.

3.2. Population fluctuations of the natural enemies associated with *P. solenopsis* on maize plants

Population fluctuations of the primary endoparasitoid, *Aenasius arizonensis* (Girault)

In Kafr El-Sheikh Governorate, Egypt, during the summer of 2021 and 2022, a single endoparasitoid called *Aenasius arizonensis* (Girault) developed from its host, the adult stage of the cotton mealybug, on maize crops. During the first season, this parasitoid was recorded in few numbers during June then increased its numbers on July and a chive the peak on 24th of July (38 individuals / sample). After that the numbers of the *A. arizonensis* have decreased gradually till the finally month of maize age, when it had recorded few numbers (Fig. 2A).

In the second the season (2022) *A. arizonensis* had similar trend. The highest peak of *A. arizonensis* on 24th of July (49 individuals / sample). Then the activity of *A. arizonensis* had decreased till the end of the season (Fig. 2B).



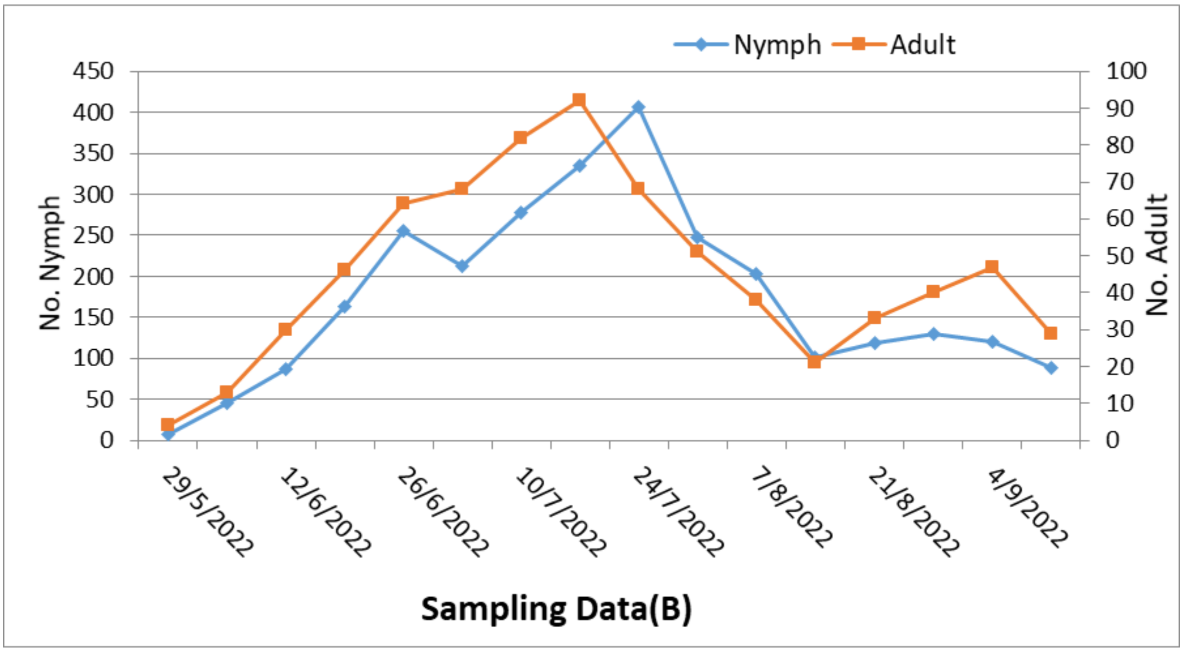


Fig. (1). Population fluctuations of *Phenacoccus solenopsis* Tinsley infesting Maize plants during season 2021(A) and 2022 (B) in Kafr El-Sheikh Governorate

Population fluctuations of predators associated with *P. solenopsis*

During this study three predators (*Chrysoperla carnea*, *Scymnus* sp. and *C. undecimpunctata*) were recorded associated with *P. solenopsis* on maize plants at Sidi Salem District, Kafr El-Sheikh Governorate, Egypt in two season (2021 and 2022). The highest activity one of the three predators was *C. carnea* followed by *Scymnus* sp. and *C. undecimpunctata*.

The highest peak of *C. carnea* was at 31st of July (17 individuals / sample) in first season 2021(Fig. 2A). In the second season highest peak of *C. carnea* was at 24th of July (20 individuals / sample) 2022 (Fig. 2B).

Scymnus sp. had recorded the highest peak was at 17th of July (10 individuals / sample) in first season 2021 (Fig. 2A). Also, in the second season highest peak of *Scymnus sp.* was at 24th of July (17 individuals / sample) (Fig. 2B).

C. undecimpunctata had recorded two peaks was at 26th of June and 17th of July (9, individuals / sample, respectively) in first season 2021 (Fig. 2A). While in the second season highest peak of *C. undecimpunctata* was at 24th of July (15 individuals / sample) (Fig. 2B).

3.3. Synchronization between *P. solenopsis* and its associated natural enemies

According to statistical study, the nymphs of *A. arizonensis* and *P. solenopsis* in the first and second seasons, respectively, had a highly significant connection (r = 0.94 & 0.96). Additionally, in both seasons, the adult *P. solenopsis* and *A. arizonensis* have a highly significant connection (r = 0.79 & 0.86; Table 1). According to statistical research, the nymphs of *P. solenopsis* and *C. carnea* in the first and second seasons had a highly significant correlation (r = 0.71 & 0.84). Additionally, in both seasons, there is a substantial association between the adult *P. solenopsis* and *C. carnea* (r = 0.60 & 0.67; Table 1).

According to statistical analysis, the nymphs of *P. solenopsis* and *Scymnus sp*. in the first and second seasons significantly correlate (r = 0.76 & 0.85). Additionally, in both seasons, there is significant correlation (r = 0.68) between the adult *P. solenopsis* and *Scymnus sp*. (Table 1).

A statistical analysis revealed a significant correlation between *P. solenopsis* and *C. undecimpunctata* nymphs in the first and second seasons (r = 0.69 & 0.82). Additionally, in both seasons, there is a substantial association (r = 0.68 & 0.66) between the adult *P. solenopsis* and *C. undecimpunctata* (Table 1).

3.4. Effect of biotic and abiotic factors on *P. solenopsis* population

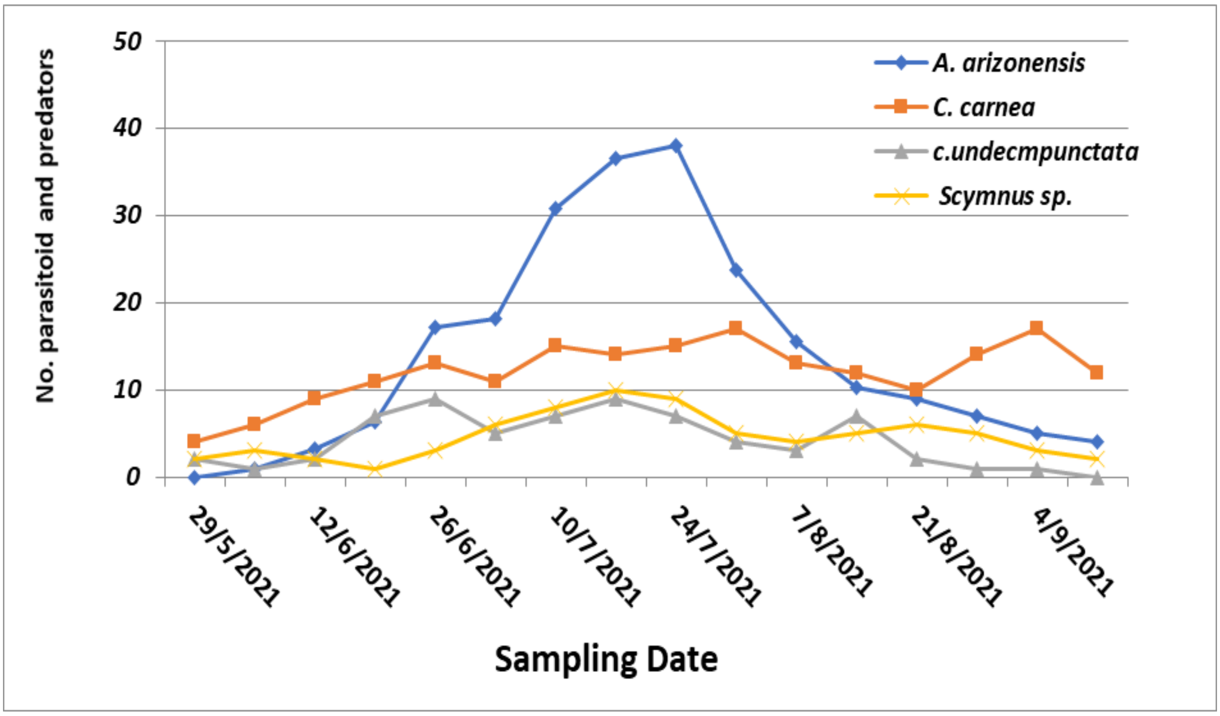
Multi regression analysis show that the combined effect of biotic factors (*A. arizonensis*, *C. carnea*, *C. undecimpunctata* and *Scymnus* sp. had highest effect between the nymph population of *P. solenopsis* (E.V = 92.18 & 94.15 %) in both seasons. Also, multi regression show the combined effect of these biotic factors had highest effect between the adult stage of *P. solenopsis* (E.V = 70.78 & 82.09 %) in both season (Table 1).

Additionally, multi regression analysis reveals that the nymphal population of *P. solenopsis* was not significantly impacted by the combined effect of climatic conditions, including relative humidity and maximum and minimum temperatures (E.V = 39.02 & 8.05 %) in both seasons. Additionally, multi regression analysis reveals that the combined impact of these meteorological parameters had little effect on *P. solenopsis* adult stage (E.V = 13.14 & 12.97%) in both seasons (Table 1).

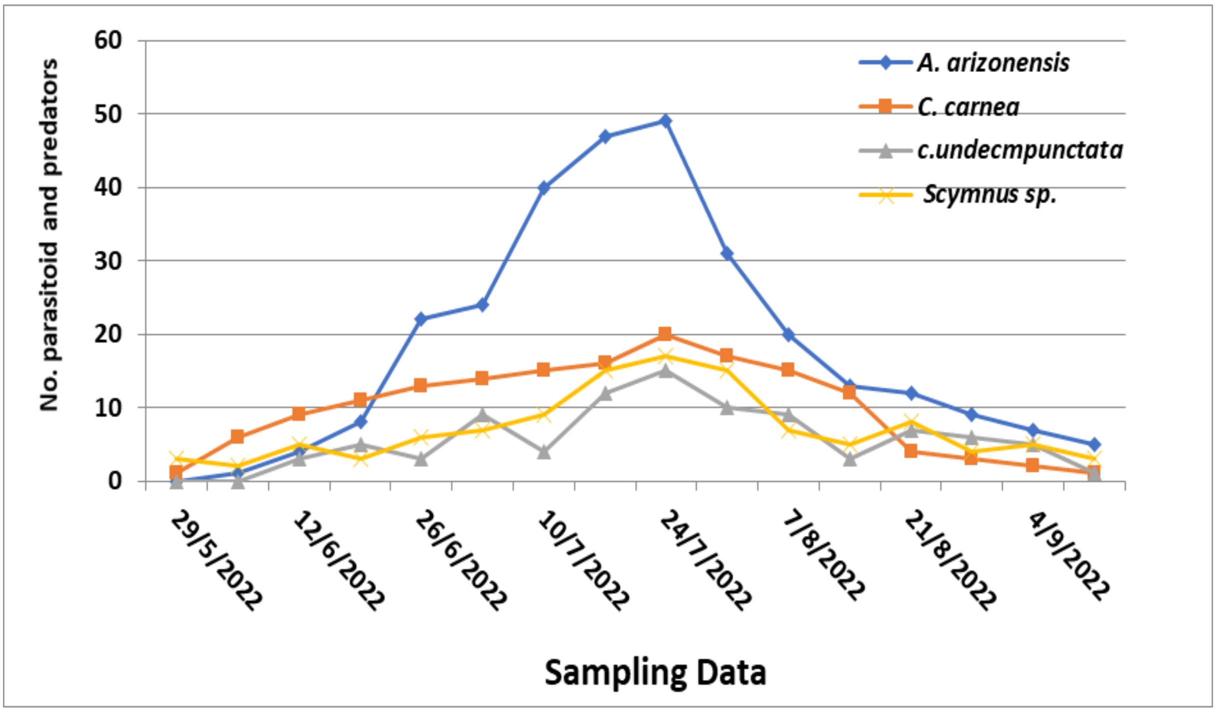
The combined impact of biotic and abiotic variables on *P. solenopsis* nymphal population reached = 94.66 & 94.28 % of the total factors effecting population in both seasons. Additionally, multi regression displays the combined effect of biotic and abiotic factors on *P. solenopsis* adult stage (E.V = 78.99 & 84.00%) in both seasons.

In this study the presence of effective predators and parasitoids, such as *C. carnea*, *C. undecimpunctata*, and *A. arizonensis*, underscores the importance of biological control in pest management strategies. Their ability to significantly reduce mealybug populations suggests that integrating these natural enemies into pest management programs could enhance crop health and yield this agreement with Abd El-Mageed et al. (2020) and Drder et al. (2024).

Overall, the study emphasizes the critical role of natural enemies in regulating *P. solenopsis* populations on maize. It suggests that effective biological control strategies should be prioritized in pest management plans to ensure sustainable agricultural practices and enhance food security in regions affected by mealybug infestations. Future research could focus on optimizing the release and conservation of these natural enemies to maximize their impact on pest populations



(A)



(B)

Fig. (2). Population fluctuations of the natural enemies associated *Phenacoccus solenopsis* feasting maize plants during season 2021(A) and 2022(B) in Kafr El-Sheikh Governorate

Table (1). The simple correlation (r) and regression coefficients (b) and multiple regressions (F and E.V. %) between the different stages of *P. solenopsis* and both of biotic and abiotic factors on maize plants in Kafr El-Sheikh Governorate

Year	Stage	Factor	r	b	P	F	E.V.%
2021	Nymph	*A. arizonensis*	0.94	6.11	<.0001	32.43	92.18
		C. carnea	0.71	16.32	0.0019		
		C. undecmpunctata	0.69	18.42	0.0030		
		Scymnus sp.	0.76	23.61	0.0006		
		T max.	0.42	15.42	0.1055	2.56	39.02
		T min.	0.50	18.30	0.0492		
		R.H.%	-0.08	-3.00	0.7613		
		All above				20.25	94.66
	Ault	*A. arizonensis*	0.79	1.23	0.0003	6.66	70.78
		C. carnea	0.60	3.24	0.0123		
		C. undecmpunctata	0.68	4.12	0.0039		
		Scymnus sp.	0.68	4.83	0.0038		
		T max.	0.31	2.60	0.2417	0.61	13.14
		T min.	0.35	2.96	0.1776		
		R.H.%	0.10	0.87	0.6998		
		All above				4.30	78.99
2022	Nymph	*A. arizonensis*	0.96	6.49	<.0001	44.23	94.15
		C. carnea	0.84	14.58	<.0001		
		C. undecmpunctata	0.82	20.58	0.0001		
		Scymnus sp.	0.85	19.86	<.0001		
		T max.	0.16	12.37	0.5462	0.35	08.05
		T min.	0.28	17.66	0.2997		
		R.H.%	0.02	0.79	0.9398		
		All above				18.83	94.28
	Ault	*A. arizonensis*	0.86	1.32	<.0001	12.60	82.09
		C. carnea	0.67	2.62	0.0044		
		C. undecmpunctata	0.66	3.74	0.0053		
		Scymnus sp.	0.68	3.57	0.0037		
		T max.	0.01	0.25	0.9579	0.60	12.97
		T min.	0.29	4.14	0.2809		
		R.H.%	-0.01	-0.11	0.9619		
		All above				6.00	84.00

REFERENCES

Abd El-Mageed S. A. M.; Abdel-Razak S. I. and Haris H. M. (2020). Ecological studies on the cotton mealybug *Phenacoccus solenopsis* (Hemiptera: Pseudocccidae) on maize in Upper Egypt. Egypt. J. Plant Prot. Res. Inst., 3 (4): 1098-1110

Arif, M. J., Gogi, M. D.; Abid, A. M.; Imran, M.; Shahid, M. R.; Husain, S. and Arshad, M. (2011). Predatory potential of some native Coccinellid predators against *Phenacoccus solenopsis*, Tinsley (Pseudococcidae: Hemiptera). Pak. Entomol., 33(2): 97-103.

Drder, M. F.; K.M. Mohanny, A. R. Attia and G. S. Mohamed (2024). Survey of mealybugs and their natural enemies at Qena Governorate, Egypt. SVU-International Journal of Agricultural Sciences, 6 (2): 163-168.

El-Rasoul, A.A.E.Y., Shehab, S.M.H. and Maghraby, H.E.S., (2020). Trends and decomposition growth analysis of the most important cereal crops in Egypt.Munich Personal RePEc Archive, no. 100231, pp. 1-10.

Ismael M. M; W. A. Eldessouki and Omar M. A (2024). Distribution of *Phenacoccus solenopsis* Tinsley on four host plants with relation to certain abiotic, biotic factors and Chemical plant contents at Kafr El-Sheikh Governorate, Egypt. Egyptian Journal of Crop Protection, 19(1):47-64.2024.

Ismael, M. M.; Abdel-Raheem, M. A.; EL-Baradey, W. M. and Abdel-Aliem, H. I. (2023). Potency of entomopathogenic fungi, as biocontrol agents on *Phenacoccus solenopsis* (Tinsley) and *Icerya seychellarum* (Westwood) at northern delta Egypt. International Journal of Agriculture and Plant Science, 5 (1):55-6

Prasad, Y. G.; M. Prabhakar, G. Sreedevi and M. Thirupathi (2011). Spatio-temporal dynamics of the parasitoid, *Aenasius bambawalei* Hayat (Hymenoptera: Encyrtidae) on mealybug, *Phenacoccus solenopsis* Tinsley in cotton-based cropping systems and associated weed flora. Journal of Biological Control, 25 (3): 198–202

Ram P and Saini R.K. (2010). Biological control of mealybug, *Phenacoccus solenopsis* Tinsley on cotton: a typical example of fortuitous biological control. J Biol Control. 24:104–109

Rashid, M.M.U., M.K. Khattak, K. Abdullah, M. Amir, M. Tariq and S. Nawaz. 2012. Feeding potential of *Chrysoperla carnea* and *Cryptolaemus montrouzieri* on cotton mealybug, *Phenacoccus solenopsis*. The Journal of Animal & Plant Sciences 22(3): 639 643.

Rishikumar, K. R. KRANTHI, D. MONGA and S. L. JAT 2009. Natural parasitization of *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) on cotton by *Aenasius bambawalei* Hayat (Hymenoptera: Encyrtidae) *J. Biol. Control*, 23(4): 457–460, 2009

Shahide, R., Jabbar, V., & Adnan, M. (2012). The Role of Insect Pests in Crop Pathology and Their Control. Journal of Agricultural Science, 10(5), 179-186.

Shera, P.S.; P. Karmakar; S. Sharma and K. S. Sangha (2017). Suitability of different mealybug species as hosts to solitary endoparasitoid, *Aenasius arizonensis* (Girault) (D *Aenasius bambawalei* Hayat. International Journal of Pest Management,63(4), 280–288.