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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

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ABSTRACT

The Cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) is an important insect pest that attacks many economically important plants. The present study monitored the population dynamics of cotton mealybugs *P. solenopsis* on eggplant, okra, cotton and molokheya plants by conducting weekly sampling during 2022 and 2023 seasons. The results indicated that nymphs and adults of *P. solenopsis* attacked eggplants more than the other three host plants. The mealybug population was showing significant effect with max. temperature and predatory insects on *e*ggplant during 2022 season. In 2023, a significant positive correlation was found with R.H, (r =0.551) and predators (r =0.811) with an Explained Variance (EV) of 44.5 % in 1st season and 68% in 2nd season. For okra plants, *P. solenopsis* showed significant positive correlation with R.H and predators. The highest infestation of *P. solenopsis* on eggplant plant was associated with highest total protein (18.73 mg/100 mg FW) and total carbohydrates (40.53mg/100mg FW). Whereas, the least infestation on cotton and molokheya plants was associated with least total protein 6.40 and 8.62 mg/100 mg FW respectively. The data included in this study lead to decide suitable management practices during effective period for *P. solenopsis* on the four tested host plants.

Key words: *Phenacoccus solenopsis*, Host plants, Chemical contents.

INTRODUCTION

Cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) is an important insect pest that offensive numerous economically important crops. Which causes huge economic losses in yield in terms of quantity and quality to various crops, which directly affects 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).It is a polyphage pest that attacks about 154 plant species including 53 plant families (Arif *et al*., 2009). Newly, the mealybug, *P. solenopsis*, was identified as an invasive insect in Egypt. The first

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record of this insect in Egypt was on weeds plants (Abd-Rabou *et al*., 2010). While, was recorded for the first time on the okra plants at summer season (Mohamed, 2021). The Cotton mealybug, *P. solenopsis* attacks, eggplants and okra plants in large numbers at different stages of growth, which affected the quantity and quality of the crop (Ibrahim, 2018 and Fargalla, 2020). The cotton mealybug *P. solenopsis* greatly affects the growth of host plants at different stages of growth in different host plants and affects crop production in terms of quantity and quality. This insect pest has also been recorded on cotton, tomato, potato and squash plant (El-Zahi *et al*., 2016; Awadalla *et al*., 2018; Ata, 2019 and Awadalla *et al*., 2019). This insect pest attacks many important plant families and moves from one host to another quickly. It has been recorded on 29 host plants arranged to sixteen plant families, three tree fruits, seven Medicinal and aromatic plants, three vegetables, thirteen weed plants, and three field crops. (Abdel-Razzik *et al*., 2015). Biological control has an effective role in reducing the mealybug population, as predators have been used successfully to control mealybugs on important economic crops. Controlling cotton mealybugs with chemical pesticides is difficult due to the presence of a waxy layer on the body 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 effective (Mohanny *et al*., 2022). Simple-correlation showed significantly and positively effect in population of *P.solenopsis* on cotton plants at minimum and maximum temperature, as the correlation at relative humidity was positive and insignificantly (El–Zahi and Farag, 2017). The highest percentage of nitrogen content of leaves was accompanied by the highest number of sucking insects (Abou Zaid *et al*., 2012). Plant phenolic content affects pest activity and development, resulting in plants resistant to insect pests (Tripathi *et al*., 2019). This experiment was conducted with the aim of studying the effect of certain biotic and abiotic factors on *P. solenopsis* population. Compare the susceptibility of four host plants to *P. solenopsis* with information on the chemical contents of the hosts.

MATERIALS AND METHODS

Field studies were carried out in the experimental field of the Sakha Agricultural Research Station, Kafr El-Sheikh governorate. An area of 504 m^2 was divided into 12 plots; each tested cultivar was represented by 3 replicates (42 m^2/ replicate) which were arranged in a randomized complete block design cultivated with cotton plants (*Gossypium barbadense* var. Giza 86), okra plants, (*Abelmoschus esculentus* (Linn.) var. white velvet), eggplant (*Solanum melongena* var. *esculenta* L.) (spherical black (classic) and molokheya plants

(*Corchorus olitorius*) wear sown in the designated date 4th week of April for two successive seasons 2022 and

2023.

Population density of *Phenacoccus solenopsis* Tinsley and its associated predators

Monitoring of *P. solenopsis* and their associated predators were recorded at weekly interval starting from 30 days after the sowing of crops. The population of adult females and nymphs of Cotton Mealybug were visually recorded by soft brush on plant, 5plants/ replicate. The specimens were collected from leaves of the tested plants and defined by entomologists at Plant Protection Research Institute, Agricultural Research Center, Egypt**.** The predatory species were counted per plant; *Scymnus* spp, larvae and adults and *Coccinella undecimpunctata*, eggs and larva of the green lacewing, *Chrysoperla carnea* (Stephens) and adults of *Orius* spp. The weather factors considered in the present work were the daily average of temperature, relative humidity. Records of these meteorologyical factors were obtained from the Central Department of Meteorological Station at Kafr El-Sheikh Governorate, Egypt

Laboratory Experiments

Effect of certain chemical components of four host plants on *Phenacoccus solenopsis* Tinsley infestation

To conduct certain special chemical analysis of four host plants, we collected fresh leaves of (Eggplant, Okra, Cotton and Molokheya plants) from insect infestation plants and control (plants without insect infestation) after that, samples were transmitting to the laboratory of plant physiology, Agricultural Botany Department, Faculty of Agriculture, Al-Azhar University for determination:

Total protein content (TP)

The Bradford method (Bradford, 1976) was used to determine protein content. The samples were treated with Bradford's solution. Absorbance was read at 595 nm using a spectrophotometer. Protein content was calculated from standard bovine serum albumin solutions of 20, 40, 60, 80 and 100 µg/mL using standard linear regression.

Total phenolic content (TPC)

It was determined by the Folin-Ciocalteau spectrophotometric method described by Singleton *et al*. (1999), using gallic acid as a standard. Absorbance was measured in a spectrophotometer at 740 nm. A blank sample was conducted under the same conditions. Results were expressed in mg GAE g-1 fresh weight.

Total carbohydrates content (TCC)

Total carbohydrates components were determined according to method of Geetha and Geetha (2014).

Statistical analysis

Statistical analysis was performed by one-way analysis of variance (ANOVA) followed by Duncan's Multiple Range test by using statistical package of social science (SPSS) version 20.0 for windows. In addition to determine correlation and regression with the biotic (predatory insects) and abiotic factors (weather

parameters) which are affecting the *Phenacoccus solenopsis* population.

RESULTS

Population density of mealybug on four host plants during 2022 and 2023 season

Data arranged in Table (1) clarified population density of mealybug on four host plants. During the first season 2022 the number of cotton Mealybug on cotton plants began with 5.6 insects / 5 plants in the 4th week of May and the highest peak of adult and nymphs of the, *Phenacoccus solenopsis* were 100 on cotton, 132 on eggplant, 109.58 on okra on and 82/5plants on molokheya plants and were recorded on 23th July, 30th July, 23th July, and 23th July, respectively. the mean number of *P. solenopsis* during 2022 season were 44.81 ±7.49, 59.3 ±9.66, 50.78±8.26 and 35.0±5.68/5 plants on cotton, eggplant, okra and molokheya plants, respectively, with significant differences between Cotton mealybug infestation and host plants.

The obtained results indicated that in 2023 season, mealybug on cotton plants recording (2.1 insects/ 5 plants) in end of May. The population has reached 91.2 on 31th of July 2023 Table (2). The highest number of adult and nymphs of the mealybug were 120/5 plants on eggplant plants and 97.10/5plants on okra plants were recorded on 7th and 14th Augusts, respectively.

Table (1): Population density of cotton mealybug, *Phenacoccus solenopsis* on four host plants during 2022 season.

Date	Mean No./ 5 plants				Mean weather factors		
	Cotton	**Eggplant**	**Okra**	**Molokheya**	**Max. Tem (C°)**	**Min. Temp. (C°)**	**R.H. %**
May, 28th 2022	5.60	7.00	6.01	2.40	31.90	22.0	61.37
Jun,4th	13.00	18.00	15.30	11.40	33.40	24.8	74.5
11th	30.00	44.00	38.10	16.10	37.40	26.8	61
18th	46.00	50.60	49.78	22.00	31.60	25.6	67.5
25th	58.60	62.00	60.34	30.60	32.80	26.2	64
Jul 2nd	56.00	70.00	64.01	40.10	32.40	26.6	69
9th	60.00	58.00	53.67	36.00	33.50	26.3	70.12
16th	69.20	100.00	86.40	40.60	31.60	24.5	70.5
23th	100.00	122.00	109.58	49.00	33.30	25.7	71.5
30th	96.00	132.00	103.70	30.00	35.00	24.9	74.0
Aug, 6th	60.00	94.00	78.10	11.40	33.00	24.8	72.5
13th	56.00	87.00	69.21	44.10	33.90	24.6	71.6
20th	30.00	38.00	29.98	16.00	33.50	25.3	74
27th	19.60	30.60	20.25	18.00	36.90	26.5	73.2
Sep3rd.	14.00	22.00	18.00	10.60	34.60	27.1	65.3
10th	3.00	14.00	10.19	2.1.00	32.50	27.2	68.8
Mean ±S. E	44.81 ±7.49 abc	59.3 ±9.66 a	50.78 ±8.26a bc	35.0±5.68c	33.5 ±0.42	25.5 ±0.31	69.3 ±1.09
L.S.D. at 5%			24.10				

Values in row followed by similar letter were not significant at 5% level of probability.

Table (2). Population density of cotton mealybug, *Phenacoccus solenopsis* on four host plants during 2023 season.

Date	Mean No./ 5 plants				**Mean weather factors**		
	Cotton	**Eggplan*t***	**Okra**	**Molokheya**	Max. Tem (C°)	Min. Temp. (C°)	**R.H. % average**
May, 29th 2023	2.10	10.00	4.50	0.60	30.50	20.80	**66.70**
Jun,5th	18.00	17.20	15.43	9.00	31.10	23.70	**67.00**
12th	40.10	44.60	42.60	13.20	32.10	23.80	**69.00**
19th	56.00	62.20	58.20	25.60	32.50	23.80	**73.00**
26th	68.00	55.40	65.90	32.00	33.00	24.30	**64.80**
Jul 3nd	58.00	62.00	59.10	49.00	32.90	24.10	**78.50**
10th	62.00	80.00	71.10	54.00	34.60	24.70	**76.10**
17th	72.00	72.00	63.85	40.00	33.50	26.00	**750**
24th	77.80	98.00	81.70	62.00	32.70	24.70	**77.10**
31th	91.20	86.00	76.31	58.20	34.40	25.00	**77.70**
Aug, 7th	84.00	120.00	81.00	49.60	35.00	25.40	**72.00**
14th	65.20	112.000	97.10	39.60	32.00	25.60	**79.70**
21th	40.00	76.00	69.24	32.00	32.80	26.10	**74.00**
28th	32.00	40.20	35.10	15.60	34.50	25.60	**75.70**
Sep 4th	18.00	30.00	21.53	9.00	33.60	25.10	**76.20**
11th	5.60	9.80	7.60	3.40	36.50	26.30	**71.30**
Mean ±S. E	49.37 ±7.0 abc	60.96 ±8.5 a	53.14 ±7.15a bc	30.80 ±5.12c	**33.23 ±0.38**	24.6 **±0.33**	73.3 ±1.12
L.S.D. at 5%			22.90				

Values in row followed by similar letter were not significant at 5% level of probability.

Population density of insect predators associated with *P. solenopsis* on cotton plants, at 2022 and 2023 season.

In the 2022 season, the average number of *Chrysoperla carnea* (Stephens) was low 2 individual /5 plants at 4th week of May and the maximum number was noticed at 2nd week of Augusts (6.0 individuals). During the second season 2023, the maximum number was recorded at the 4th week of Augusts 6.6 individual (Figs. 1A and B).

For the eleven spotted lady-beetle*, C. undecimpunctata* the maximum number was listed at 3rd week of July (4.0 individual) in 1st season and 6.5 individual at 1st week of Augusts in 2nd 2023season (Fig. 1A and B).

As for, ladybirds*, Scymnus* spp., the maximum number during two seasons of study was 5.0 individual (Fig. 1A and B). The highest beak of *Orius* spp. was recorded on 2nd week of Augusts (4.5 0 adults/5plants) at 2022 season and (6.0 adults/5plants) on 3rd week of Jun at 2023 season (Fig. 1A and B).

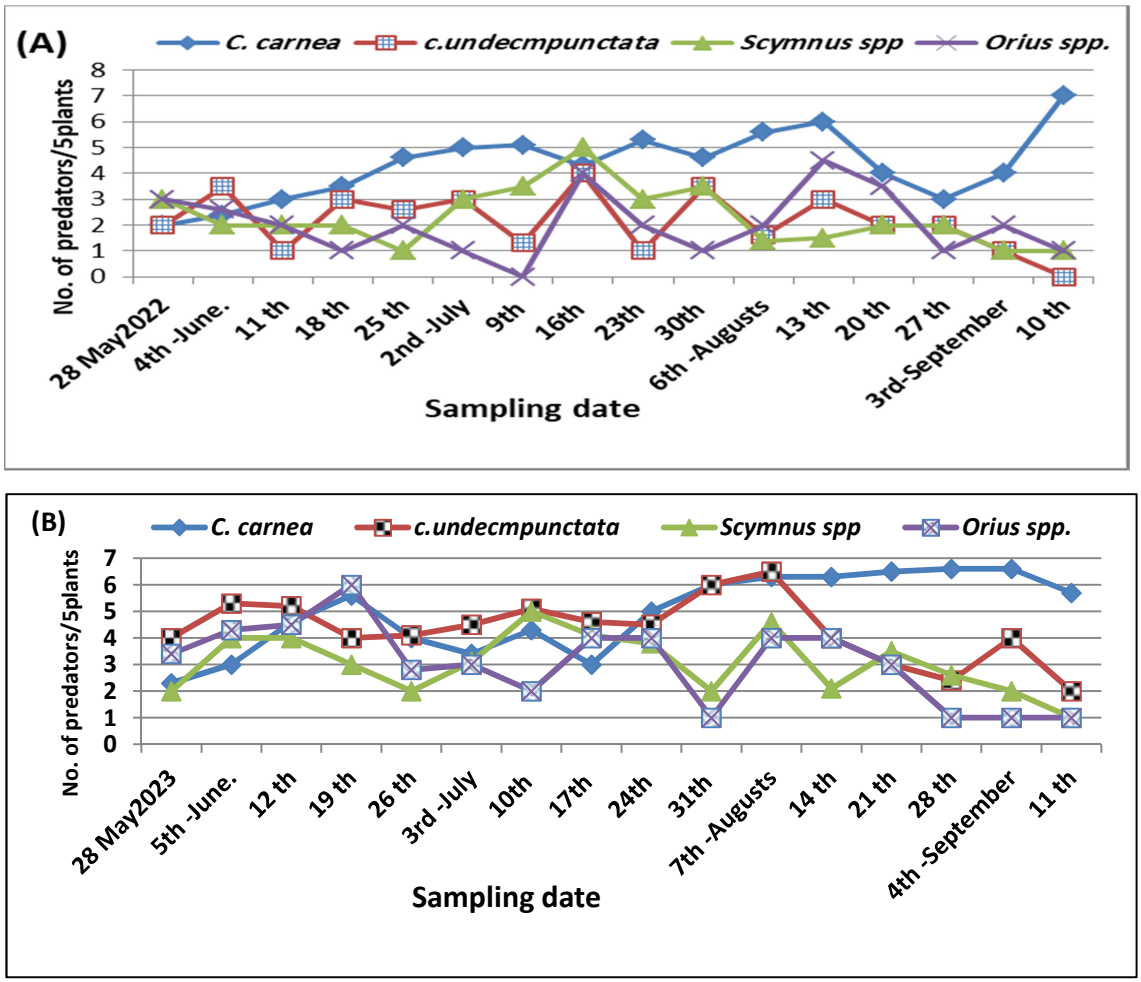

Fig. 1: Mean numbers of insect predators on cotton plants in 2022 season (A) and 2023 season (B).

Population density of Insect Predators associated with *P. solenopsis* on okra plants, during first and second season

In the 2022 season, the average number of *Chrysoperla carnea* (Stephens) was low 3 individual/5 plants at 4th week of May and the maximum number was noticed at 2nd week of September 7.6 individual (Fig. 2A). In 2023 season, the maximum number was recorded at the 4th week of Augusts 6.6 individual (Fig. 2B).

For the eleven spotted lady- beetle, *C. undecimpunctata* the maximum number was listed at 2nd week of Augusts (4.0 individual) in 1st season and 8.6 individual at 3rd week of July in 2023 season (Fig. 2A and B).

As for, ladybirds, *Scymnus* spp., the maximum number during two seasons of study was 3.9 individual recorded at 2nd week of July and 4 individuals in 3rd week of Augusts during 2022 and 2023 seasons, respectively (Fig. 2A and B). The highest beak of *Orius spp* was recorded on 3rd week of Augusts (6 adults/5plants) at 2022 season and (5.0 adults/5plants) on 3rd week of Jun at 2023 season (Fig. 2A and B).

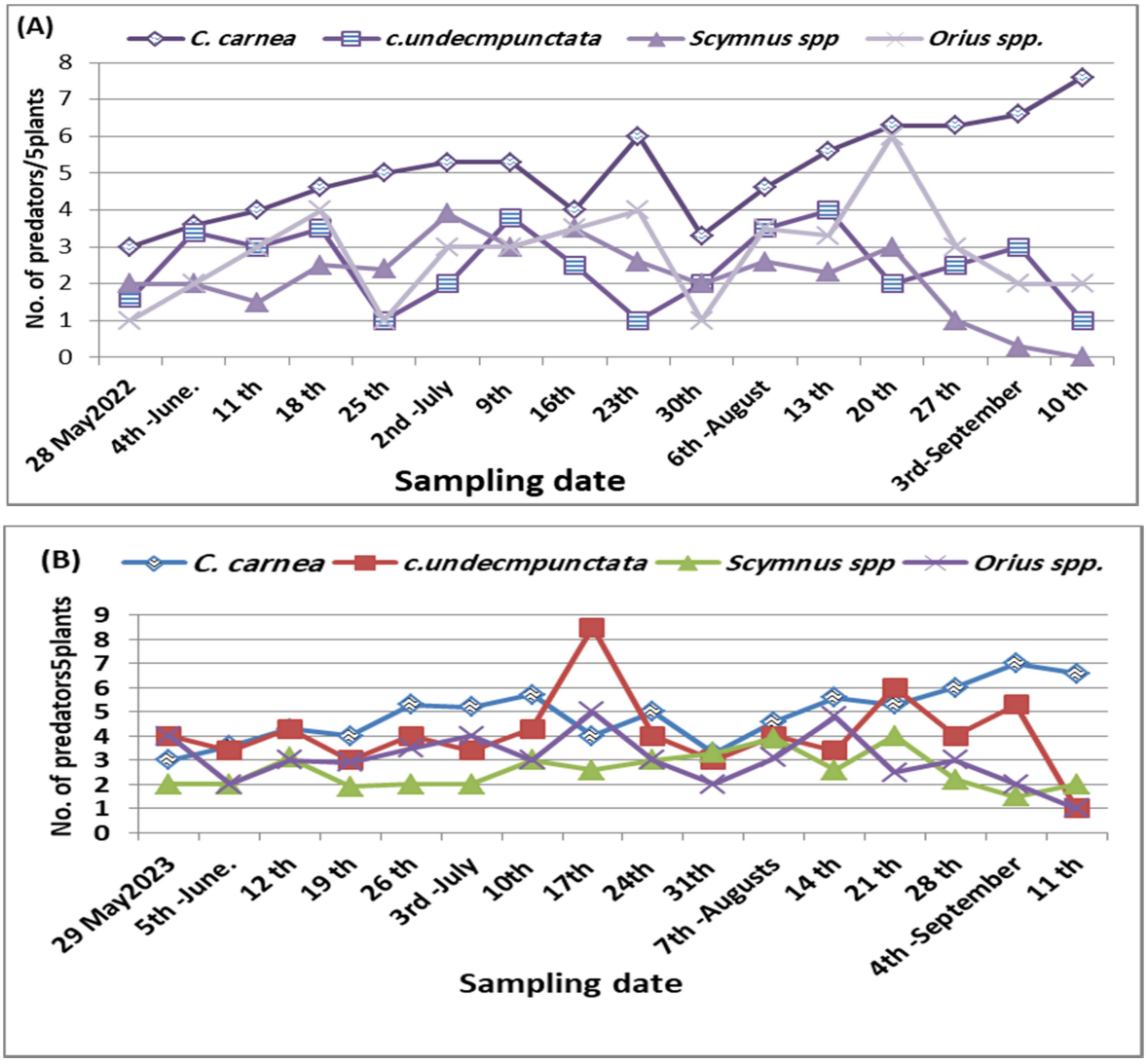

Fig. 2: Mean numbers of predatory insects on okra plants during 2022 season (A) and 2023 season (B).

Population density of Insect Predators associated with *P. solenopsis* on eggplant plants during first and second season

The maximum number of *C. carnea* during 2022 season was recorded at 1st week of September as 9.6 individuals (Fig. 3A). In 2023 season, the number of *C. carnea* was 2 individual/5 plants at 4th week of May and the maximum number was noticed at 1st week of September (6.51 individual) (Fig. 3B).

For the eleven spotted lady- beetle, *C. undecimpunctata* the maximum number was listed at 1st week of August (5.10 individual) in 1st season (Fig. 3A). and 5.4 individuals at 3rd week of July in 2023 season (Fig. 3B).

In the 2022 season, the number of *Scymnus* spp. started with 2.3 individual /5 plants at 1st week of June and the maximum number was listed at 3rd week of July 5.1 individual (Fig. 3A). The maximum number of *Scymnus* spp. in 2023 season was 5.10 recorded at 2nd week of July (Fig. 3B).

The highest beak of *Orius* spp. was recorded on 3rd week of August (4.5 adults/5plants) at 2022 season and (5.3 adults/5plants) on 4th week of July at 2023 season (Fig. 3A and B).

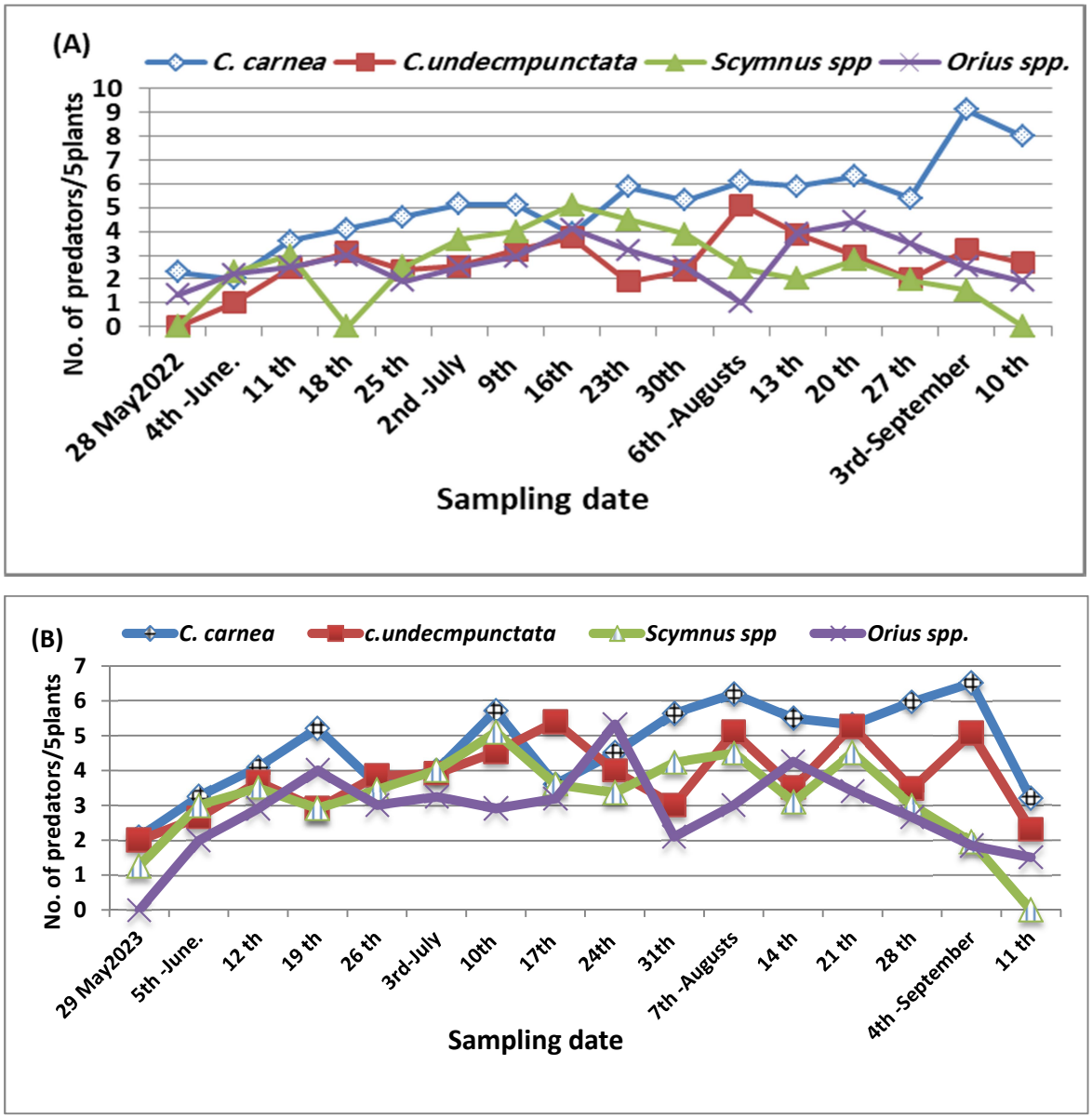

Fig. 3: Number of insect predators on eggplant plants in 2022 season (A) and 2023 season (B).

Population density of insect predators associated with *P. solenopsis* on molokheya plants during first and second season

The maximum beak of *C. carnea* was recorded on 2nd week of September (7.6 individual /5 plants) at 2022 season and (7.0 individual /5 plants) on 2nd week of September at 2023 season (Figs. 4A and B).

For the eleven spotted lady- beetle, *C. undecimpunctata* the maximum population (4.0 eggs and larva) was listed at 1st week of Augusts (4.0 individual) in 1st season (Fig. 4A). and 4.3 individual at 1st week of July in 2023 season (Fig. 4B).

As for, Ladybirds, *Scymnus* spp., the maximum number predator during two seasons of study was 4.5 individual recorded at 3rd week of July

and 5.5 individual in 3rd week of August during 2022 and 2023 seasons, respectively (Fig. 4A and B).

The highest beak of *Orius* spp. was recorded on 3rd week of August (2.5 adults/5plants) at 2022 season and (3.3 adults/5plants) on 1st week of July at 2023 season (Fig. 4A and B).

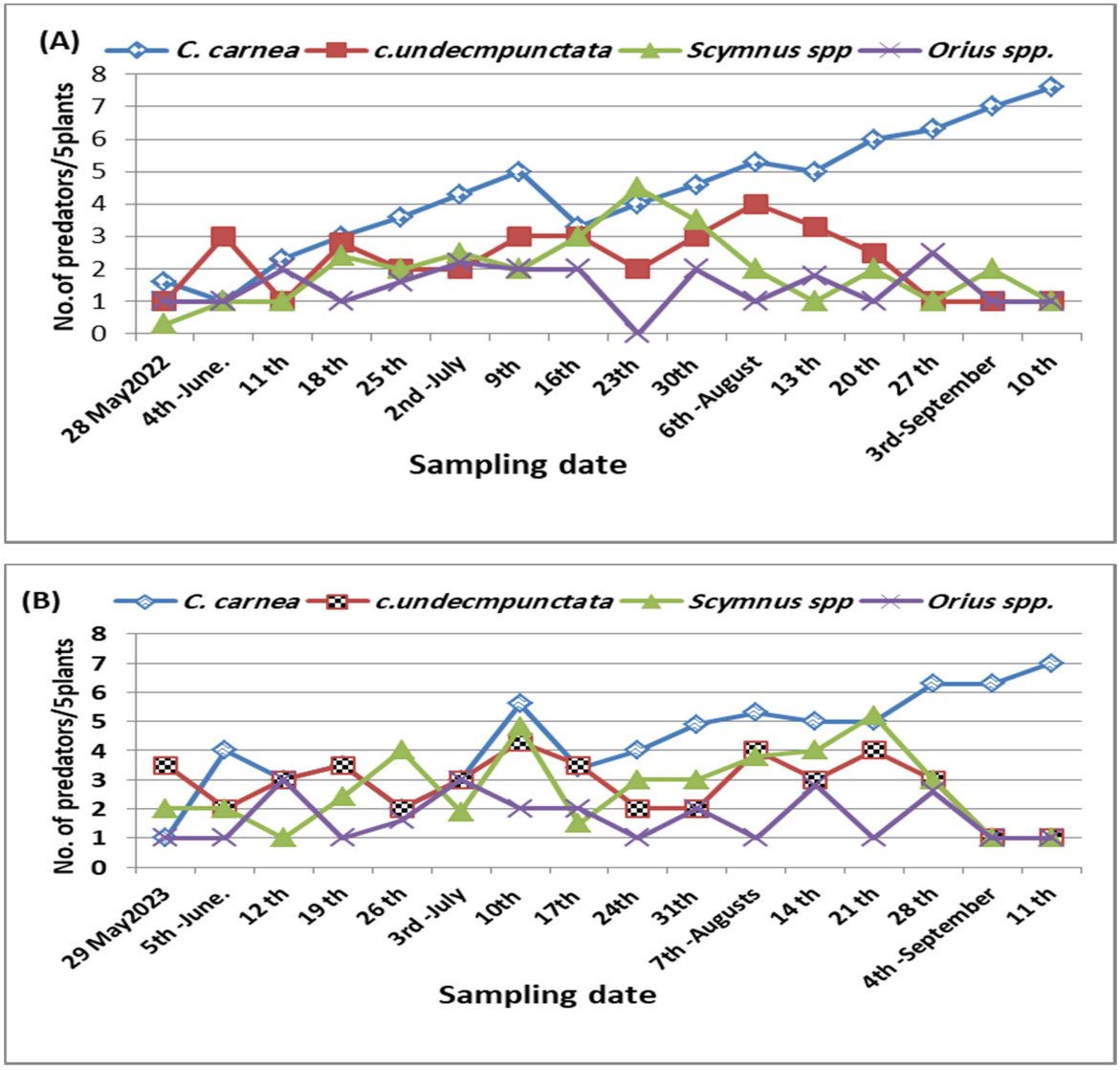

Fig. 4: Number of insect predators on molokheya plants during 2022 season (A) and 2023 season (B).

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

Phenacoccus solenopsis population is not significant negative correlated with max. and min. temperature and the r values were-1.102 and -0.053, respectively at 1st season 2022 (Table-3). The relationship was significant with total predatory insects, r = 0.543. The combined effect of a biotic factors, predators and *P. solenopsis* was presented as explained variance (E.V.) which was 35.2%.

In 2023 season, the mealybug population was showing insignificant for max. temperature, r = 0.19; min. temperature, r = 0.31 and R.H, r =0.42),

whereas, the insect population was significant with predators, r = 0.576. The combined impact of a biotic factors, predators and *P. solenopsis* were 48.7%.

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

In 1st season 2022, the effect of max. temperature and predators had significant and positive effect on the population density of *P. solenopsis* and "r" = -0.051 and 0.533, respectively, whereas, the relationship were insignificant with min. temperature, r = -0.103 and R.H, r =0.388. The combined impact of a biotic factors, predators and *P. solenopsis* were 44.2%. (Table 3).

In 2nd season 2023, the relationship was significant and positive between R.H, r =0.551 and predators r = 0.811and population of *P. solenopsis*. (Table 3). The effect of max. and min. temperature was insignificant and positive on the population density of *P. solenopsis* "r" =0.153 and 0.399, respectively. The combined effect was 68%. (Table 3).

Table (3): Correlation and Regression of *Phenacoccus solenopsis* with certian Abiotic and biotic factors on cotton and e*ggplant* plants during 2022 and 2023.

Host plants	YEAR	Source of variation	Simple correlation		Partial regression		E.V%
			r	**p**	**b**	**P**	
Cotton	**2022**	Max. temperature °C	-1.102	0.701	1.500	0.768	35.20%
		Mini. temperature °C	-0.053	0.834	4.433	0.506	
		R.H	0.32	0.212	0.629	0.740	
		Predators	0.543*	0.030	7.475	0.071	
	2023	Max. temperature °C	0.198	0.484	3.690	0.539	48.70%
		Mini. temperature °C	0.311	0.421	-0.401	0.956	
		R.H	0.424	0.102	1.856	0.259	
		Predators	0.576*	0.021	5.448	0.029	
Eggplant	**2022**	Max. temperature °C	-0.051	0.085	0.417	0.942	44.20%
		Mini. temperature °C	-0.103	0.750	-12.501	0.163	
		R.H	0.388	0.137	0.700	0.766	
		Predators	0.533*	0.03	7.442	0.038	
	2023	Max. temperature °C	0.153	0.570	0.410	0.943	68.00%
		Mini. temperature °C	0.399	0.126	-2.457	0.750	
		R.H	0.551	0.027	1.201	0.483	
		Predators	0.811**	0.00	6.942	0.006	

EV=explained variance RH= relative humidity

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

In 1st season, the effect of maximum, mini. temperature, R.H and predatory insects had not significant Table (4), whereas, in 2nd season 2023 the relationship were significant positive effects with R.H, r =0.524 and predators r = 0.475. The combined effect of a biotic factor, predators and *P. solenopsis* were 12% and 39.2% in first and second seasons, respectively.

Effect of abiotic and biotic factors on

***P. solenopsis* population on molokheya plants**

In1st season 2022, the effect a biotic factor on *P. solenopsis* were insignificant and "r" values were -0.104, 0.062, and 0.260 respectively, while the relationship was not significant and positive with predators r = 0.437. The explained variance was 20%. (Table 4).

In 2nd season 2023, the relationship was significant and positive between R.H, r = 0.580 and predators r =0.466 and population of *P. solenopsis*. (Table 4).

Mealybug population had insignificant and positively correlated with maximum and minimum temperature, r = 0.216 and 0.305, respectively. The combined effect was 39%. (Table 4).

Table (4): Correlation and Regression of *Phenacoccus solenopsis* with certian Abiotic and biotic factors on okra and molokheya plants during 2022 and 2023.

Host plants	Year	Source of variation	Simple correlation		Partial regression		E.V %
			r	p	b	p	
Okra	2022	Max. temperature °C	-0.118	0.663	-1.889	0.764	12.40%
		Mini. temperature °C	-0.078	0.77	-1.105	0.895	
		R.H	0.327	0.217	2.273	0.364	
		Predators	0.185	0.494	0.696	0.869	
	2023	Max. temperature °C	0.093	0.731	-3.345	0.634	39.20%
		Mini. temperature °C	0.390	0.135	4.800	0.598	
		R.H	0.524	0.037	2.374	0.203	
		Predators	0.475*	0.063	2.919	0.382	
Molo-kheya	2022	Max. temperature °C	-0.104	0.702	-0.674	0.804	20.00%
		Mini. temperature °C	0.062	0.818	-1.123	0.780	
		R.H	0.260	0.330	-0.119	0.924	
		Predators	0.437	0.091	2.957	0.230	
	2023	Max. temperature °C	0.216	0.422	0.617	0.894	39.00%
		Mini. temperature °C	0.305	0.251	-1.797	0.765	
		R.H	0.580*	0.019	2.227	0.122	
		Predators	0.466*	0.069	1.939	0.415	

EV=explained variance RH= relative humidity

Relationship between four host plants leaf chemical composition and *P solenopsis* populations during 2022 and 2023 seasons

Table 5 shows the percentages of total protein, total phenols and total carbohydrates of infested and non-infested (control) of four host plants. The highest chemical constituents such as total protein (18.73 mg/100 mg FW) were detected in eggplant plant, followed by okra (9.79 mg/100 mg FW), molokheya (8.68 mg/100 mg FW) and cotton plants (6.40). It is important to clear that eggplant harbored the highest infestation of *P. solenopsis* (60.13 individuals/5plants) more than other three hosts during the two studied seasons with the highest

value of total protein (18.73 mg/100 mg FW) where total carbohydrates, total phenols were 40.53 mg /100 mg FW and 2.71 mg/g FW, respectively. Values of total protein and total carbohydrates were decreased after insect infestation in *eggplant* plants and recorded 10.17mg/100 mg FW and 28.03 mg/100 mg FW, respectively.

On the other side, the lowest infestation by *P. solenopsis* recorded on molokheya plants (32.9 individuals/5plants) with low level of total protein (8.62 mg/100 mg FW) and maximum value of total carbohydrates 46.61 mg/100 mg FW with total phenols 2.00 mg /g FW. It is clear from the classified results that the *P solenopsis* insects prefer plants high in protein content and a medium percentage of carbohydrates and phenols content.

Table (5) Chemical composition of four host plants and *P. solenopsis* populations (mean of two seasons)

plants		**Total protein** (mg/100 mg FW)	**Total carbohydrates** (mg /100 mg FW)	**Total phenols** (mg/g FW)	Mean No. of *P. solenopsis*
Cotton	**Control**	6.40	35.81	3.79	-
	Infested plants	5.67	32.08	3.85	47.09±2.26
Eggplant	**Control**	18.73	40.53	2.71	-
	Infested plants	10.17	28.03	2.78	60.13±0.83
Okra	**Control**	9.79	36.13	2.68	-
	Infested plants	7.55	29.71	2.88	51.96±1.18
Molokheya	**Control**	8.62	46.61	2.00	-
	Infested plants	4.70	37.57	2.31	32.9±2.1

DISCUSSION

The recorded data revealed that the *P. solenopsis* attacked eggplants more than the other three host plants okra cotton and molokheya plants during 2022 and 2023 seasons. The results are in conformity with the findings of El-Zahi *et al*., (2016), where they reported that the mean number of *P. solenopsis* per cotton plant was 96.8±7.9. The highest numbers of *P. solenopsis* on okra and eggplant plants were noticed during 3rd week of August and 1st week of September (El-Fakharany, 2020). Maximum number of *P. solenopsis* spotted at September (Shah *et al.*, 2015). Also, Nabil (2017) found that the maximum number of *P. solenopsis* on eggplant plants were recorded in June, July, August and September. (Nabil *et al*., 2020). indicated that, *P. solenopsis* infested okra plants from the 1st week of March until the end of July, and had three peaks per season, which were recorded in the 1st week of April, 3rd week of May, and 4th week of June. March month was the least favorable during two seasons. (Bakry and Fathipour, 2023).

The results of the insect predators associated with mealybug on the host plants are in parallel with the findings of Ibrahim (2018) who showed that insect predators found with *P. solenopsis* on cotton plants were *Scymnus syriacus* and noticed from June to August, *C. carnea* from August to December, *Orius laevigatus* from June to August and *C. undecimpunctata* from November to Feb. Also, 5 larvae *C.carnea* per 100 nymphs of *P. solenopsis* can be used as a biological control against *P.solenopsis* during the management programme. Ismail (2018) also noticed that *C. carnea* insect predator on okra plants recorded maximum number in 3rd and 4th week of July at the 1st and 2nd seasons, respectively while *C. undecimpunctata* showed three peaks of activity in the 4th week of June, 2nd week of July and 2nd week of Augusts. Kaur *et al.*, (2008) reported that *C. carnea* larvae were consume 30 eggs of mealybug daily in developmental laboratory tests. Average maximum population of insect predators, Coccinellids and Chrysoperla associated with *P. solenopsis* were 0.28 and 0.2 per host plant (Singh and Kumar, 2012).

The results of the simple-correlation on cotton plants showed that *P. solenopsis* population was insignificant negative correlated with max. and min. temperature and the relationship was significant with total predatory insects in 1st season. In 2023 season, the mealybug population was showing insignificant for max. temperature, min. temperature and R.H whereas, the population was significant with predators.

Hanchinal *et al*. (2010) they found that mealybug population was significantly and positively correlated with max. temperature r= 0.775, min. temperature and R.H. Singh and Kumar (2012) recorded that *P.solenopsis* on cotton and okra plants showed positive correlation with maximum temperature and population of Coccinellid predators whereas negative correlation with minimum temperature and relative humidity. In Pakistan, insect predators showed positive correlation with mealybug, *P. solenopsis* population. Sahito *et al*. (2011). Also, (El-Sarand, 2017 and El-Zahi and Farag, 2017) recorded that temperature and relative humidity had a negative and insignificant effect on *P. solenopsis* population in two seasons with exception of effect of temperature in 2nd season it was significant negative. Bakry and Fathipour (2023) reported that max. temperature was the least effective factor in population changes during both season. While relative humidity was the most active mutable on P. solenopsis population.

The highest chemical constituents such as total protein were detected in eggplant plants, followed by okra, molokheya and cotton plants with highest infestation of *P solenopsis* on eggplant plants whereas, the lowest infestation by *P. solenopsis* recorded on molokheya plants with low level of total protein and maximum value of total carbohydrates with total phenols. It is clear from the classified results that the *P solenopsis* insects prefer

plants high in protein content and a medium percentage of carbohydrates and phenols content. The cotton mealybug attacking a wide range of host plants with various odor components (Vennila *et al.,* 2013). The results are in conformity with the findings of Shehata (2020) how reported that the highest chemical constituent's percentage such as total terpenoids (13.5%) were registration in okra plant, keep track of eggplant (7.44%), pepper (3.93%), cowpea (3.31%). on the other hand, the maximum of females density were in host plants reared through nymphal stage on leaves of okra (80.18±6.7%). whereas, the lowest percentage of females was 36.14±10.1 on pepper plants. Also, (Shehata and Moussa, 2018) Found that the maximum infestations of *P solenopsis* insects were on okra and eggplant plants. El-Batran *et al.* (2016) they reported that quantity and quality of the nutritional needs with chemical analysis of the plant such as, crude protein and total carbohydrates are the fundamental operator affecting on citrus mealybugs development. Therefore, variation of the host plant species and their chemical contents affects the food choice behavior, rest and increase of polyphagous insect pest. Du *et al.,* (2004). Stated that relation of the aphids population and total protein and carbohydrates were insignificant positive correlation. As well, Mohamed (2021) mentioned that allocation of *P. solenopsis* on okra plant is relevant to the age of the plant and the position of infestation.

CONCLUSIONS

The present study revealed the population dynamic of *P. solenopsis* and their predators on eggplant, okra, cotton and molokheya plants with the maximum population being recorded on eggplant and recording of abiotic and biotic components to embed the typical time for execute pest control. Chemical contents of four tested plant hosts affects the insect infestation of *P. solenopsis*. The obtained results are important in integrated pest management programs (IPM) of *P. solenopsis* on eggplant, okra, cotton and molokheya plants.

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REFERENCES

Abdel-Razzik, M. I.; Attia, A. R. And Abdel-Aziz, M. (2015). Newly host plants of cotton mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Psedococcusdae) in Egypt. *Egyptian Academic Journal of Biological Sciences*, 8(3):31-33.

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

Abu-Zaid, A. M.; Bakr, E. M. and Hameed, N. A. (2012). Abundance of three sap sucking pests on three eggplant cultivars with utilization of *Phytoseiulus persimilis* Athias-Henriot against *Tetranychus urticae* Koch, *Acarines,* 6: 49-53.

Ata, T. E. (2019). Biological studies on the cotton mealybug *Phenacoccus solenopsis*Tinsley (Hemiptera: Pseudococcidae) under the laboratory conditions. *Journal of Plant Protection and Pathology. Mansoura University,* 10(3): 195-198.

Arif, M. I., Rafiq, M and Ghaffar, A. (2009). Host plants of cotton mealybug (Phenacoccus solenopsis): a new menace to cotton agroecosystem of Punjab, Pakistan. *International Journal of Agriculture and Biology*, 11: 163-167.

Awadalla, H. S. S.; El-Kady, H. A. and Eisa, M. M. A. (2018). Effect of planting dates on the cotton mealybug *Phenacoccus solenopsis*(Tinsley) as a main insect pest attacking tomato plants in Damietta Governorate. *Journal of Plant Protection and Pathology. Mansoura University,* 9(3): 167-169.

Awadalla, S. S.; Abd Allah, F. D.; El-Serafi, H. A. K. and Badawy, W. B. F. (2019). Influence of different plantations on the main piercing-sucking insect pests attacking faba bean and soybean plants. *Journal of Plant Protection and Pathology. Mansoura University,* 10(5): 289-292.

Bakry, M. M.; and Fathipour, Y. (2023). Population Ecology of the Cotton Mealybug, Phenacoccus solenopsis (Hemiptera: Pseudococcidae) on Okra Plants in Luxor Region, *Egyptian Journal of Agriculture Science. Technology*. 25(6): 1387-1402.

Bradford, M. M. (1976). A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. *Analytical Biochemistry*, 72(1), 248-254.

Du, L.; Ge, F.; Zhu, S. and Parajulee, M. N. (2004). Effect of the cotton cultivar on development and reproduction of A*phis gossypii* (Homoptera: Aphididae) and its predate *Propylaea japonica* (Coleoptera: Coccinellidae). *Journal of Economic Entomology*, 97: 1278-1283.

El-Batran, L. A.; Awadalla, S. S.; Fathy, H. M. and Shareef, Q. (2016). Effects of different host plants on

the biological aspects of the citrus mealybugs *Planococcus citri* Risso (Homoptera: Pseudococcidae). *Journal of Plant Protection and Pathology. Mansoura University,* 7(1): 1-4.

El-Fakharany, S. K. (2020) Cotton mealybug *Phenacoccus solenopsis* (Hemiptera: Pseudococcidae) population density in eggplant and okra plantations and effect of some insecticides. *Egyptian Journal of Plant Protection Research Institute,* 3 (1): 377 – 388.

El-Sarand, E. A. (2017) The Cotton Mealybug, *Phenacoccus Solenopsis* Tinsley (Homoptera : Pseudococcidae) as a New Insect on Soybean Plants in Egypt and its Population Dynamic. *Journal of Plant Protection and Pathology. Mansoura University, 8 (11): 545 – 548*.

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

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.

Fargalla, F. H. (2020). Effect of different Vegetable Crops on the Population Density of the Cotton Mealybug, *Phenacoccus solenopsis* (Tinsley) (Hemiptera: Pseudococcidae) in Mansoura Region. *Journal of Plant Protection and Pathology. Mansoura University,* 11(1):41-45.

Geetha, T. S. and Geetha, N. (2014). Phytochemical screening, quantitative analysis of primary and secondary metabolites of *Cymbopogan citratus* (DC) stapf. leaves from kodaikanal hills, Tamilnadu. *International Journal of pharmtech research*, 6(2): 521-529.

Hanchinal, S. G.; Patil, B. V.; Bheemanna, M. and Hosamani, A. C. (2010). Population dynamics of mealybug, *Phenacoccus solenopsis* Tinsley and its natural enemies on Bt cotton. *Karnataka Journal of Agricultural Science*, 23(1): 137-139.

Ibrahim, S. S. (2018). Study on Cotton Host Plants of Mealybug *Phenacoccus solenopsis* (Tinsley) and Efficiency Release the Predator *Chrysoperla carnea* (Stephens) for its Controlling on Cotton Plants in Egypt. *Journal of Plant Protection and Pathology. Mansoura University,* 9 (3): 247 – 252.

Ismail, H. A. (2018). The main sucking insect pests and their associated predators on okra plants. *Journal of Agricultural Research*, 45 No. (4) p1257-1271.

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.

Kaur R.; Kaur, R. and Brar, K. S. (2008). Development and predation efficacy of *Chrysoperla carnea* (Stephens) on mealy bug, *Phenacoccus solenopsis* (Tinsley) under laboratory conditions. *Journal of Insect Science* (Ludhiana), 21(1):93-95.

Mohyuddin, A. L.; Jillani, G.; Khan, A.G.; Hamza, A.; Ahamad, I. and Mahmood, Z. (1997). Integrated pest management of cotton pests by conservation, redistribution and augmentation of natural enemies in Pakistan. *Pakistan Journal of Zoology 29: 393–398.*

Mohamed, G. S. (2021). 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, *Egyptian Academic Journal of Biological Sciences*, 14(3): 1-16.

Mohanny, K. M.; Mohamed, G. S.; Bakry, M. M. S.; Ali, M. K. and Allam, R. O. H. (2022). Toxicity of three insecticides and some alternatives against cottony cushion scale, *Icerya purchasi* (Maskell) under laboratory conditions. SVU-*International Journal of Agricultural Sciences*, 4 (3): 135-142.

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*, 10(7): 195–206.

Nabil, H. A.; Ismail, I. M.; Elashtokhy, M. M.; Hegab, M. A. (2020). The Monitoring and Molecular Identification of the Mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) on Okra Plants at Sharkia Governorate. *Egyptian Academic Journal of Biological Sciences*, 12(2):241-248.

Sahito, H. A.; Abro, G. H.; Sayed, T. S.; Lanjar, A. G.; Mal, B. and Khajjak, S. (2011). Seasonal population abundance of cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) and its natural enemies on various hosts plants*. Pakistan Journal of entomology* Karachi, 26 (1): 25-40.

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

Shehata, I. E. and Moussa, S. F. (2018). Infestation rate and management of the cotton mealybug, *Phenacoccus solenopsis*

(Hemiptera: Pseudococcidae). *Bioscience Research*, 15(4): 4252-4266.

Shehata, I .E.; Mostafa, M. E. and Salama, H. S. (2020). Biology and host preference of the cotton mealybug, *Phenacoccus solenopsis* tinsley (Hemiptera: Pseudococcidae) on different host plants. *Plant Archives*. 20, 461-471.

Singh, A and Kumar, D. (2012). Population dynamics, biology of mealybug *Phenacoccus solenopsis* (Tinsley) and its natural enemies in Vadodara, Gujarat. *Recent Research in Science and Technology*, 4(11): 22-27.

Singleton, V.; Orthofer, R. and Lamuela-Ravento´s, R. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. In L. Packer (Ed.). Oxidants and antioxidants, part A. *Methods in Enzymology*, 299:152–178.

Tripathi, D.; Raikhy, G. and Kumar, D. (2019). Chemical elicitors of systemic acquired resistance-salicylic acid and its functional analogs. *Current Plant Biology*, 17, 48–5949.

Vennila, S.; Prasad, Y. G.; Prabhakar, M.; Meenu, A.; Sreedevi, G. and Bambawale, O.M. (2013). Weed hosts of cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae). *Journal of Environmental Biology*, 34 (2):153-158.

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