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Marwa ES Amer
Department of Scale Insects and Mealybugs, Plant Protection Research Institute, ARC, Egypt

Sanaa AM Abd El-Mageed
Department of Scale Insects and Mealybugs, Plant Protection Research Institute, ARC, Egypt

Soad I Abdel-Razak
1. Department of Scale Insects and Mealybugs, Plant Protection Research Institute, ARC, Egypt
2. Department of Biology, University of Hafr Al batin, Faculty of Sciences, Saudi Arabia

Corresponding Author:
Soad I Abdel-Razak
1. Department of Scale Insects and Mealybugs, Plant Protection Research Institute, ARC, Egypt
2. Department of Biology, University of Hafr Al batin, Faculty of Sciences, Saudi Arabia

Coccoidea infesting goldenberry, *Physalis peruviana* L. with ecological and control studies of the cotton mealybug, *Phenacoccus solenopsis* tinsley (Hemiptera, Coccomorpha, Pseudocccidae) from Egypt

Marwa ES Amer, Sanaa AM Abd El-Mageed and Soad I Abdel-Razak

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Abstract
The promising untraditional crop, Goldenberry, *Physalis peruviana* L. rapidly cultivated in many countries as a demand of fruit as in fresh markets; medicinal purposes; developing processing industry and rapid growing of exportation. Unfortunately, the plant recognized highly infesting by many Coccoidea species in Qalyubiya Governorate, Egypt thus experiments conducted to survey, population fluctuations and control of the most found prominent species.

During the survey study period a total of four Coccoidea species following four genera belonging to two families of Supper family Coccoidea were recorded three of them were recorded for the first time infesting *Physalis peruviana* L as well as a total of six predators and two parasitoids recorded associated with the collected species. Data obtained indicated that, the most dominant Coccoidea species was the cotton mealybug, *Phenacoccus solenopsis* causing a severe infestation reducing the quantity and quality of the goldenberry crop therefore the study on this pest covers a population fluctuations and number of generations as well as its associated natural enemies during two successive growing seasons of 2019-2020 and 2020-2021.

The results obtained clarified that *P. solenopsis* Tinsley have three peaks of abundance in both seasons in the selected goldenberry orchards with a very low effective of the recorded parasitoid, *Dicrodiplosis manihoti* Harris.

The correlation of the selective abiotic factors (maximum & minimum temperature and relative humidity) and biotic factors (natural enemies) with the population fluctuation of the cotton mealybug were studied. A control study conducted to evaluate the highest and safest alternative pesticide to reduce the pest especially with lake of sufficient parasitoid found during the period of study. This study could be a great help to understand the endemicity of the species and the best way to control without several problems such as, pesticide residual, pest resistance, secondary pest outbreaks.

Keywords: Goldenberry, mealybugs, *Phenacoccus solenopsis*, ecology, control

Introduction
Goldenberry, *Physalis peruviana* L. (Fam: Solanaceae) recently considered one of the most promising untraditional crops in the world, due to its wonderful taste, high nutritional value, and high potential health benefit in treating many diseases (Puente *et al*., 2011; Wu *et al*., 2005; Stary, 1983; Perry & Metzger, 1980) [37, 46, 39, 36]. The fruit has spread worldwide, and localized industries have developed in South America, South Africa, Australia, New Zealand, and India but large-scale commercial production is not common (Durner, 2019) [18].

In Egypt a great attention is directed for promoting this promising crop to meet the progressive demand of local fresh markets, medicinal purposes, developing processing industry and rapid growing of exportation (Mustafa, 2009) [32].

Accordingly, Attentions are directed widely to the pests infesting goldenberry which reduce its quality and quantity. (Koshy *et al.* 1978; Morton, 1987; Liquido *et al*., 1994; Mehta *et al*., 1996; Bado *et al*., 2000; Bado *et al*., 2001; Bado *et al*., 2005; Tropea Garzia, *et al*., 2009 and Parmar, 2012) [26, 29, 28, 30, 12-14, 45, 51].

In Egypt, many insect pests recorded attacking the goldenberries orchards. A survey study conducted by Afsah, in 2015 at Qalubia governorate found the presence of 22 insect pest species and 5 insect predators associated with *Physalis peruviana* orchards, from them the mealybug, *Planococcus citri* Risso (Hemiptera: Pseudococcidae) which recorded infesting plant leaves.

The families Pseudococcidae (mealybugs) and Monophlebidae include small scale insects (Coccoidea: Hemiptera) that suck out plant sap. Feeding by these pests can cause premature leaf, flower, and fruit drop, reduce plant vigour, and discolour tissues. In addition, they secrete honeydew upon which sooty-mold fungi grow, reducing photosynthesis and attracts ants that protect these pests from predators and parasitoids. (Peri and Kapranas, 2012) [38].

The cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera, Coccomorpha, Pseudocccidae) considered as a serious pest of Cotton in Pakistan and India since 2005. From that time, he pest spread widely Infesting many host plants belonging to different plant families. (Arif *et al.*, 2009; Abd-Rabou *et al.*, 2010; Abbas *et al*., 2010; Fallahzadeh *et al*., 2014 Badr, *et al*., 2020; and Abd El-Mageed *et al*, 2020) [2, 4, 3, 21, 16, 11].

From its recorded in Egypt in 2010 the pest was spreading rabidly infesting different host plants (Ibrahim *et al*., 2015; Attia, and Abdel Aziz, 2015; Abdel- Razzik *et al.*, 2015; Abd El-Wareth, 2016; Beshr, *et al*., 2016; Moharum *et al.*, 2017 and Abd El-Mageed *et al*, 2020) [25, 8, 6, 9, 15, 33, 11]. Accordingly, many studies were conducted on the Ecology, population density, dynamical fluctuations, associated natural enemies and biology of *Phenacoccus solenopsis* on many host plants (Nabil, 2017; Shehata, 2017; Nabil, and Hegab, 2019; Abd El-Mageed *et al*, 2020) [34, 44, 35, 11].

Many control studies conducted to reduce its population by using natural and chemical compounds as well as measuring the effect of natural enemies to reduce the pest population level below the economic threshold (Mohyuddin *et al*. 1997; Dinesh *et al*. 2003; Sunitha *et al*. 2009; Ahmad *et al*. 2011; Gross *et al*. 2001; Suresh *et al*. 2010; El-Zahi *et al*., 2016) [31, 17, 40, 5, 22, 41, 20].

Thus, this work aimed to Survey of Coccoidea species and its associated natural enemies infesting the promising untraditional crop, *Physalis peruviana L* as well as ecological and population fluctuation and number of generations of the cotton mealybugs, *Phenacoccus solanepsis* and its associated natural enemies and the most biotic and abiotic factors affecting the insect population during two seasons, 2019-2020 and 2020-2021. with evaluation of safe alternative application to control the species.

To the best of our knowledge depending on literature cited this work includes the first record of the cotton mealybug, *Phenacoccus solenopsis* L. (Pseudococcidae); the Pink-hibiscus mealybug, *Maconellicoccus hirsutus* (Green) (Pseudococcidae); and the Seychellarum mealybug, *Icerya seychellarum* (Westwood) (Monophlebidae) as a new pest of goldenberry *Physalis peruviana L*. widely (Scale Net. 2022). Consequently, this study could be a great help to understand the endemicity of the species and the best way to control without several problems such as, pesticide residual, pest resistance, secondary pest outbreaks.

Materials and Methods

1. Survey of Coccoidea species infesting goldenberry, *Physalis peruviana* L. and the associated natural enemies at Banha locality, Qalyubiya Governorate during two successive seasons (2019-2020 & 2020-2021)

To survey Coccoidea species infesting goldenberry orchards during two seasons (2019-2020 and 2020-2021), the selected orchards for the investigation did not receive any chemical control treatments. A total of 25 leaves randomly collected for two weeks ‘intervals. Samples transferred immediately to the laboratory for counting and classifying the existing individuals of detected species. Both upper and lower surface of the leaves were examined. As for classifying the collected species, either temporary or permanent slides making techniques were made of the mature adult female as stated by (McKenzie,1969) [28]; (Ezz, 1965) [19] and (Sirisena *et al*., 2013) [43] and examined microscopically and then classified taxonomically using scale insect’s keys.

The found Coccoidea species kept in glass jars separately under laboratory conditions (25-30 °C and 65-70% R.H) for 30 days to recognize any emerged parasitoids. The emerged parasitoids were transferred to 70% ethyl alcohol and later identified using specific keys.

Regarding the associated predators, during the field survey, predators were collected using an aspirator, when observed, or by shaking the plant. The collected predators identified using specific keys.

2. Population fluctuations and number of generations of the cotton mealybugs, *Phenacoccus solenopsis* Tinsley and its associated natural enemies on goldenberry, *Physalis peruviana* L. at Banha locality, Qalyubiya Governorate during two seasons of 2019-2020 & 2020-2021

Field experiments were carried out during two seasons (2019-2020 and 2020- 2021.) in untreated goldenberry orchard Variety Balady. Ten trees were selected for carrying out this study. Samples (ten leaves and 5 small branches) were taken randomly from all directions of each tree weekly during the investigation period. Samples were put in cloth bags and transferred to the laboratory to classify and count the existing individuals by using stereoscopic binocular microscope. The upper and lower surface of the leaves were examined. All stages of the insect as well as parasitized stages of the inspected insects were counted and recorded. The associated predators were also recorded and identified.

The formula proposed by (Audemard and Milaire 1975) [1] and emended by (Iacob, 1977) [24] was applied for estimating the number of *P. solenopsis* generations and their durations.

3. Effects of some weather factors on the *Phenacoccus solenopsis* Tinsley populations infesting goldenberry, *Physalis peruviana* L. at Banha locality, Qalyubiya Governorate during two seasons of 2019-2020 & 2020-2021

The prevailing air temperature, maximum and minimum air temperature (°C) and relative humidity percentage (RH %) in the experimental area during the periods of the present study were obtained from the Central Laboratory for Agricultural Meteorology, Agricultural Research Center, Ministry of Agriculture. The relationships between the tested weather factors and each insect population were studied.

4. Testing of some safe alternative pesticides for controlling the cotton mealybugs, *Phenacoccus solenopsis* Tinsley on goldenberry, *Physalis peruviana* L. at Banha locality, Qalyubiya Governorate during two successive years

Field experiments were conducted in the goldenberry orchard located in Benha district, Qaliobiya Governorate, Egypt during two seasons (2019-2020 &2020-2021) to suppressing the population and controlling the pest by using some safe alternatives of pesticides as shown in (Table,1). Samples of 25 leaves were picked up from each replicate directly before spraying as a pretreatment replicates. The post-treatment replicates were replicated 5 times and collected after 5, 7, 14, 21 and 30 days after spraying application. The corrected reduction percentage of cotton mealybugs were estimated according to the equation of (Henderson and Tilton 1955) [23].

Table 1: List of Control treatments (Petroleum oil, Jojoba oil and Sulfur) and their rates of applications.

Treatments	Rate of application/100 L water
Super Oil (95 % EC Mineral oil)	1.5 L/100 L water
Jojoba Oil (Oil extract)	300 cm/100 L water
Saflon® (Liquid Sulfer 70% SC sulfer)	200 /100 L water

Statistical analysis

Simple correlation, partial regression values and coefficient of determination percentage (C.D. %) were calculated using COSTAT Computer Program (2005).

Results and Discussion

1. Survey of Coccoidea species infesting goldenberry, *Physalis peruviana* L. and the associated natural enemies at Banha locality, Qalyubiya Governorate during two successive seasons

Data in (Table, 2) asserted that a total of four Coccoidea specie following four genera belonging to two families of Supper family Coccoidea were observed infesting goldenberry, *Physalis peruviana* L. at Banha locality, Qalyubiya Governorate during two successive seasons of (2019-2020 & 2020-2021).

The collected species could be listed taxonomically as follows: the Cotton Mealybugs, *Phenacoccus solenopsis* L. (Pseudococcidae); the Pink-hibiscus mealybugs, *Maconellicoccus hirsutus* (Green) (Pseudococcidae); the Citrus mealybugs, *Planococcus citri* (Risso) (Pseudococcidae) and the Seychellarum mealybugs, *Icerya seychellarum* (Westwood) (Monophlebidae).

During the study period a total of six predators recorded associated with the collected Coccoidea which could be listed as follows:

Hyperaspis vinciguerrae Capra, *Nephus hiekei* Furch, *Rodolia cardinalis* (Mulsant) (Coleoptera, Coccinellidae). *Orius albidipennis* (Reuter) (Hemiptera, Anthocoridae); *Chrysoperla carnea* (Steph) (Neuroptera, Chrysopidae).

A total of two parasitoids recorded and could be listed as follows:

Dicrodiplosis manihoti Harris (Hymenoptera: Encyrtidae) infesting the cotton mealybug, *Phenacoccus solenopsis* Tinsley and *Anagyrus kamali* Moursi parasitoids of the pink hibiscus mealybug *Maconellicoccus hirsutus* (Green).

2. Population fluctuations and number of generations of the cotton mealybugs, *Phenacoccus solenopsis* Tinsley and its associated natural enemies on goldenberry, *Physalis peruviana* L. at Banha locality, Qalyubiya Governorate during two seasons of 2019-2020 & 2020-2021

Data illustrated in Table 3 and Figs. (1a, 1b & 2a, 2b) show the half monthly counts of *P. solenopsis* Tinsley stages and associated natural enemies, infesting Goldenberry orchard during two successive years of (2019-2020&2020-2021).

During the first season of 2019-2020, the obtained results of the total number of all stages of *P. solenopsis* reached its maximum during Mid of September 2019 comprised 3401 /100 leaves; then showed a pronounced decreased up to 76/100 leaves during the first of April 2020.

Thereafter, the mean counted insects/100 leaves increased gradually again from the beginning of May 2020 reached its maximum of 1588 insects/ 100 leaves during the mid of July 2020 of the first season of 2019-2020. (Table, 3 and Fig, 1a, 1b)

In the second growing season (2020-2021) a merely similar trend of fluctuating calculations was also detected. The mean counted insects per 100 leaves was obviously lower during mid of September 2020 resembled 2320 /100 leaves continued its decrease up to a minimum of 104 / 100 leaves during the mid of March 2021.

in April 2021; the counted insects gradually began to rein crease again from 104 individual / 100 leaves in first of April 2021 and reached the maximum in Mid of July resembled 1568 individual per 100 leaves, (Table,3 & Fig. 2a, 2b).

Herein, the data listed in Tables, 3&4 and Figs. (1a, 1b & 2a, 2b) could be showed that the estimated densities of fluctuating population of the cotton mealy bug, *Phenacoccus solenopsis* Tinsley on the leaves of goldenberry, *Physalis peruviana*, throughout both the following growing seasons of 2019-2020 and 2020-2021 proved three distinctly prominent peaks for each. From Table, 3 and Figs. (1a & 2a), the first occurred peak observed in first of August until mid of October, 2019 resembled a total of 75 days in the growing season of 2019-2020; the second peak was in the first of November 2019 until the mid of April, 2020 with a total of 165 days; the Third was in the first of May until mid of July with 105 days of accumulation. (Table, 4)

Merely the same beaks of generation obtained in the second season of 2020-2021, the first peak was observed from the first of August until first of November with 90 days of occurrence; the second from 15 November up to first of April, 2021 resembled 165 days of occurrence the third peak of generation occurred during mid of April to mid of July with 105 days of accumulation. (Table, 4)

Concerning the Population fluctuations of the associated natural enemies of *P. solenopsis* infested goldenberries orchards at Benha locality, Qalyubiya Governorate during the two years of (2019-2020 & 2020-2021) Data illustrated in table Table, 3 and Figs. (1b & 2b) showed that the highest number of total individual natural enemies population during the study period was to the associated predator *Hyperaspis vinciguerrae* Capra (Coleoptera, Coccinellidae) with a total population of 661 and 462 individuals during the study sesons season of 2019-2020 and 2020-2021 respectively. Its population began to increase from the beginning of August comprised 38&22 individuals during both seasons respectively and slightly reached its highest individual in the mid of September comprised 112&58 individuals during both seasons respectively; during late Autumn; winter and early

spring months its population individuals decreased slightly reached zero during mid of march 2020 of the first season and during mid of February 2021 of the second season. Its population began to increase again from first of April 2020 of the first year and first of March, 2021 of the second year reached its highest peak in mid of July 2020 for the first season and first of July, 2021 of the second season.

The second effective natural enemy collected associated with *Phenacoccus solenopsis* Tinsley on goldenberry orchard was the predator *Chrysoperla carnea* (Steph) (Neuroptera, Chrysopidae) with a total population of 388 and 267 individuals during the first season of 2019-2020 and 2020-2021 respectively. Its population began to increase from the beginning of August comprised 10&5 individuals during both seasons respectively and slightly reached its highest individual in the mid of September comprised 43&22 individuals respectively during both seasons. It is worth to mention here that during winter and early spring months its population individuals was very low reached from zero-2 individuals in both seasons. From mid of March its population began to increase again for both two seasons reached its maximum 45&26 individuals during 15 July 2020 of the first season) and first of July 2021 of the second season respectively.

The less abundant natural enemies were the were *Nephus hiekei* Furch, (Coleoptera, Coccinellidae) and *Orius albidipennis* (Reuter) (Hemiptera, Anthocoridae) with a total population individual of 146&151 and 189&189 respectively during the two growing seasons 2019-2020&2020-2021 with a high level of counted individuals during summer and spring months.

During the experiment period we recorded the Encyrtid parasitoid, *Dicrodiplosis manihoti* Harris (Hymenoptera: Encyrtidae) infested the cotton mealybug, *P. solenopsis* with a total population individual reached 112&147 during both seasons.

The seasonal activity of *Dicrodiplosis manihoti* was illustrated for the both seasons Table, 3 and Figs. (1b & 2b)

In both seasons of the study period of 2019-2020 and 2020-2021 the first appearance for the parasitoid was in 1st of August with successively achieved of two peaks. the first peak was recorded in 15th of October reached 12&15 parasitoid individuals, and the second peak was in 15th of July with a total counted individuals of 22&24 for both seasons of the study period respectively.

3. Effects of some weather factors on the *Phenacoccus solenopsis* Tinsley populations infesting goldenberry, *Physalis peruviana* L. at Banha locality, Qalyubiya Governorate during two seasons of 2019-2020 & 2020-2021

During the study period of 2019-2020 and 2020-2021, The simple correlation (r) and regression coefficients (b) and multiple regressions (E.V.%) of the biotic (natural enemies) and abiotic factors (maximum and minimum temperature & RH%) related to the total population individuals of *P. solenopsis* infesting goldenberries orchard shown in (Table 5a&b and Fig 3, a&b) indicated that The total population of *P. solenopsis* infested goldenberry orchard significantly positive correlated with maximum and minimum temperature in both years of study, while with RH% was insignificantly negative in both years.

The total population of *P. solenopsis* infested goldenberry orchard significantly positive correlated with the predator *Hyperaspis vinciguerrae* Capra (Coleoptera, Coccinellidae) followed by *Chrysoperla carnea* (Steph) (Neuroptera, Chrysopidae) with a less insignificant positive correlated with *Nephus hiekei* Furch, (Coleoptera, Coccinellidae); *Orius albidipennis* (Reuter) (Hemiptera, Anthocoridae) and the Encyrtid parasitoid, *Dicrodiplosis manihoti* Harris (Hymenoptera: Encyrtidae).

Multiple regression (E.V%) between total *P. solenopsis* population and weather factor (abiotic factor) was (E.V.%) 81.59% and 66.66% respectively during both seasons of the study. Whereas, multiple regression between total *P. solenopsis* population and biotic factors was (E.V.%) 83.77% and 88.72% on both year of study respectively (Table 5a&b)

Data obtained indicated that, there were significantly positive correlated relationship between the insect population and maximum and minimum temperature in both years of study while with RH% it was insignificantly negative in both years. That is agree with (Singh and Kumar, 2012) who stated that the Mealybug population is positively correlated with maximum temperature whereas it shows negative impact of humidity. While Coccinellid predators and percentage of parasitoids as biotic factor shows strong significant positive correlation with mealybug population.

4. Testing of some safe alternative pesticides for Controlling the cotton mealybug, *Phenacoccus solenopsis* Tinsley on goldenberry, *Physalis peruviana* L. at Banha locality, Qalyubiya Governorate

to achieve management of studied pest at tolerable levels, the choosing time of spraying considers a critical concern. Therefore, During July 2020 and 2021, the cotton mealybug, *P. solenopsis* infested goldenberry trees in large numbers caused great damage to the trees and the fruits. Therefore, this experiment was carried out to evaluate the effect of three safe alternative pesticides summer mineral oil (super oil) at the rate of 1.5 L/100 L water; Plant extract oil (Jojoba oil) at the rate of 300 cm/100 L water and Saflon (Liquid Sulfer 70% SC sulfer) at the rate of 200 cm /100 L, beside an untreated control treatment.

Data presented in Table, 6 and Fig. 4 showed that, the summer mineral oil (super oil) was ratherly efficient and gave the highest total reduction percentage of 81.18% & 77.75% respectively during the two season of 2020&2021due to its relative rapid mode of action after spray application in the summer season.

Herein, according to the calculated averages of reduction percentages of *P. solenopsis*, the three evaluated safe alternative pesticides could be arranged in the following descending order: Super oil (81.8%) & (77375%) > Jojoba oil (74.04%) & (71.01%) > super Saflon (58.13%) & (51.96%) respectively during the two-experiment period.

It is worth to mention here that during the experiment months, the rate of parasitized individuals of the cotton mealy bug, of *P. solenopsis*, by the recorded parasitoid *Dicrodiplosis manihoti Harris* was low to the limit that the effect of tested applications on the activity of that parasitoid couldn't be calculated.

Table 2: Survey of Coccoidea species infesting *Physalis peruviana* L. and the associated natural enemies at Benha locality, Qalyubiya Governorate during seasons 2019-2020 and 2020-2021.

Order	Family The recorded	pest		The associated predators			The associated Parasitoid		
				Order	Family	Scientific name	Order	Family	Scientific name
Hemiptera	Pseudococcidae		Cotton Mealybugs *Phenococcus solenopsis* L	Coleoptera	Coccinellidae	*Hyperaspis vinciguerrae Capra*	Hymenoptera	Encyrtidae	*Dicrodiplosis manihoti* Harris
			Pink-hibiscus mealybug, *Maconellicoccus hirsutus* (Green)	Coleoptera	Coccinellidae	*Nephus hiekei Furch*	Hymenoptera	Encyrtidae	*Anagyrus kamali* Moursi
			Citrus mealybug, *Planococcus citri* (Risso)	Coleoptera	Coccinellidae	*Rodolia cardinalis* (*Mulsant*)	-	-	-
	Monophlebidae	Seychellarum mealybug, *Icerya seychellarum* (Westwood)		Neuroptera	Chrysopidae	*Chrysoperla carnea* (*Steph.*)	-	-	-
				Hemiptera	Anthocoridae	*Orius albidipennis* (*Reuter*)			

Table 3: Half monthly counts of different developmental stages of *Phenacoccus solenopsis* Tinsley infesting goldenberry and the associated natural enemies at Benha locality, Qalyubiya Governorate during the first and second seasons 2019-2020 & 2020-2021

Date of inspections	Number of stages /100 leaves						Total		No. of natural enemies									
	Nymphs		Adult female		Gravid females				*Hyperaspis vinciguerrae Capra*		*Chrysoperla carnea* (*Steph.*)		*Nephus hiekei Furch*		*Orius albidipennis* (*Reuter*)		*Dicrodiplosis manihoti Harris*	
	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021
1-Aug., 2019	1434	979	354	317	215	113	2003	1409	38	22	10	5	8	5	5	8	9	14
15-Aug.	1455	1245	386	349	245	101	2086	1695	44	30	18	17	4	5	6	8	16	10
1-Sep.	2231	1678	507	504	308	129	3046	2311	100	49	55	31	8	6	9	13	5	4
15-Sep.	2408	1543	614	544	379	233	3401	2320	112	58	43	22	11	10	6	10	6	7
1-Oct.	929	816	259	436	152	90	1340	1342	50	55	26	20	11	8	11	11	7	5
15-Oct.	1018	1022	238	389	111	65	1367	1476	32	39	11	14	8	11	10	12	12	15
1-Nov.	847	676	204	301	78	57	1129	1034	20	49	20	10	5	3	21	15	5	3
15-Nov.	750	569	168	245	70	50	988	864	13	10	14	10	5	3	16	21	5	3
1-Dec.	210	167	29	51	18	22	257	240	10	3	0	4	2	0	5	3	0	2
15-Dec.	297	112	34	40	16	10	347	162	5	0	0	2	1	0	6	0	0	1
1-Jan.2020	152	88	30	22	14	7	196	117	4	0	0	0	1	0	3	0	0	1
15-Jan.	145	67	22	10	9	6	176	83	3	0	0	0	0	0	4	0	0	0
1-Feb.	110	50	20	6	5	2	135	58	2	0	2	1	0	0	2	0	0	0
15-Feb.	106	56	15	6	3	2	124	64	0	0	2	0	0	0	1	0	0	0
1-Mar.	90	60	10	5	3	2	103	67	0	3	2	0	0	0	1	0	0	1
15-Mar.	95	88	8	5	2	1	105	94	0	3	7	3	3	5	1	0	1	3
1-Apr.	70	95	5	8	1	1	76	104	3	5	10	4	4	5	10	5	2	3
15-Apr.	78	112	2	11	0	1	80	124	5	6	12	8	4	6	13	6	4	6
1-May.	538	476	29	61	7	7	474	544	5	8	18	10	7	10	2	9	4	6
15-May.	501	576	57	98	10	15	605	689	8	12	15	10	5	8	1	11	1	5
1-Jun.	598	660	96	124	10	23	704	807	16	10	27	21	9	11	6	10	1	9
15-Jun.	605	711	104	210	18	28	727	949	35	24	18	28	11	16	11	17	2	11
1-Jul.	1219	1016	257	260	25	30	1501	1306	75	45	33	26	36	21	21	19	10	14
15-Jul.	1187	1243	344	288	57	37	1588	1568	81	31	45	21	21	18	18	11	22	24
Total	17010	14105	3792	4290	1756	1032	22558	19427	661	462	388	267	164	151	189	189	112	147

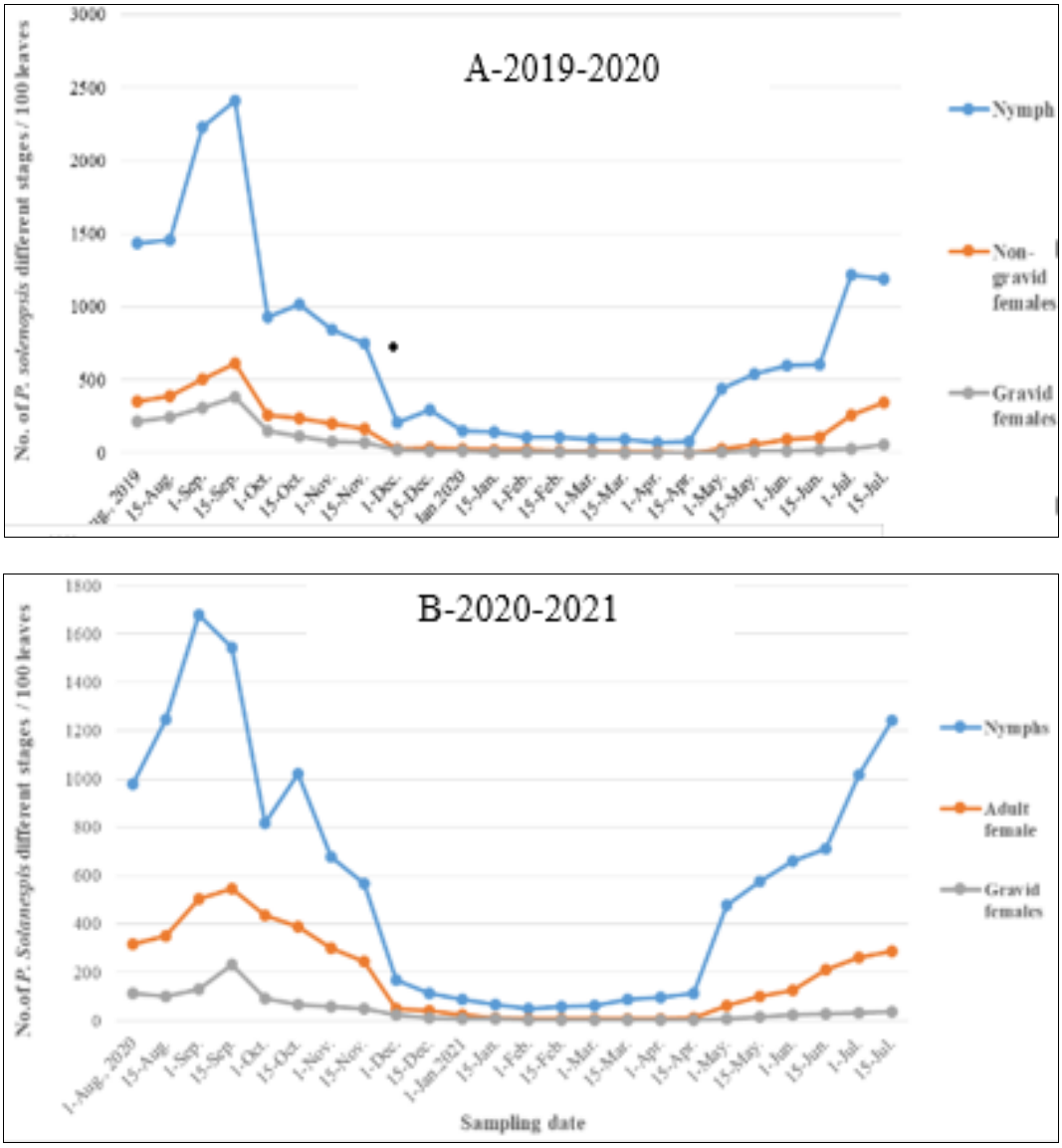
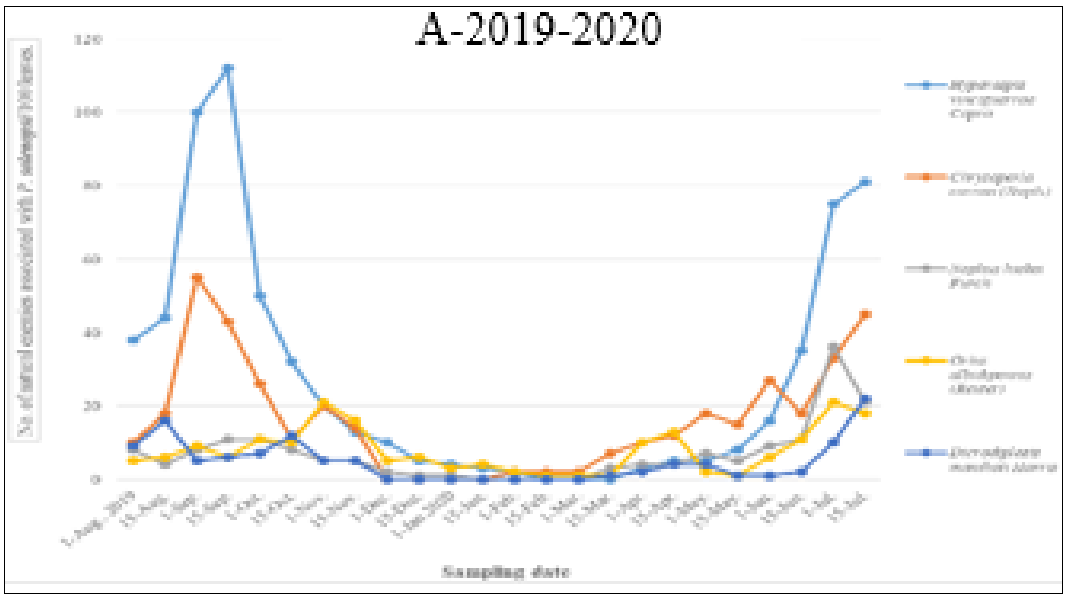


Fig (1 a & b): Population fluctuations of different stages of *P. solenopsis* Tinsley on *Physalis peruviana* L. at Benha locality, Qalyubiya Governorate during two years of 2019-2020&2020-2021



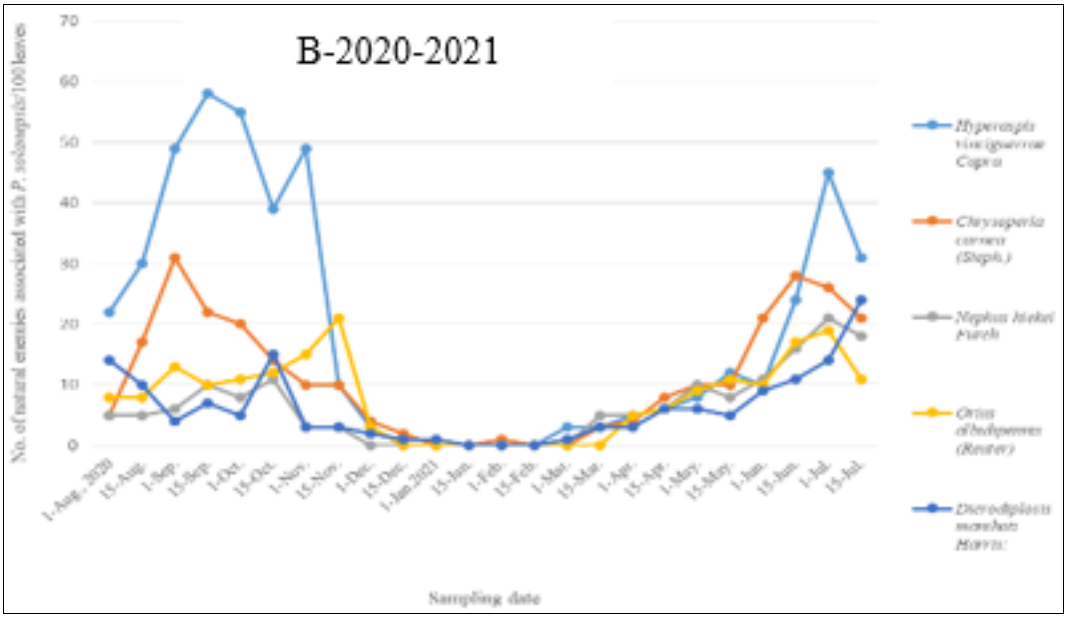
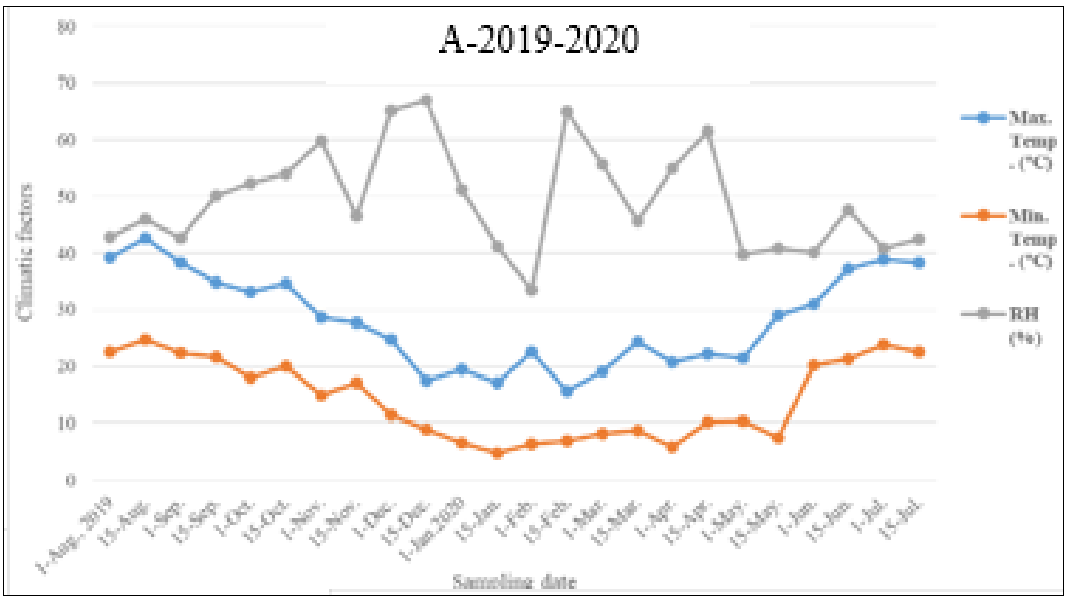


Fig (2 a&b): Population fluctuations of the natural enemies associated with *P. solenopsis* Tinsley on *Physalis peruviana* L. at Benha locality, Qalyubiya Governorate during two years of 2019-2020&2020-2021



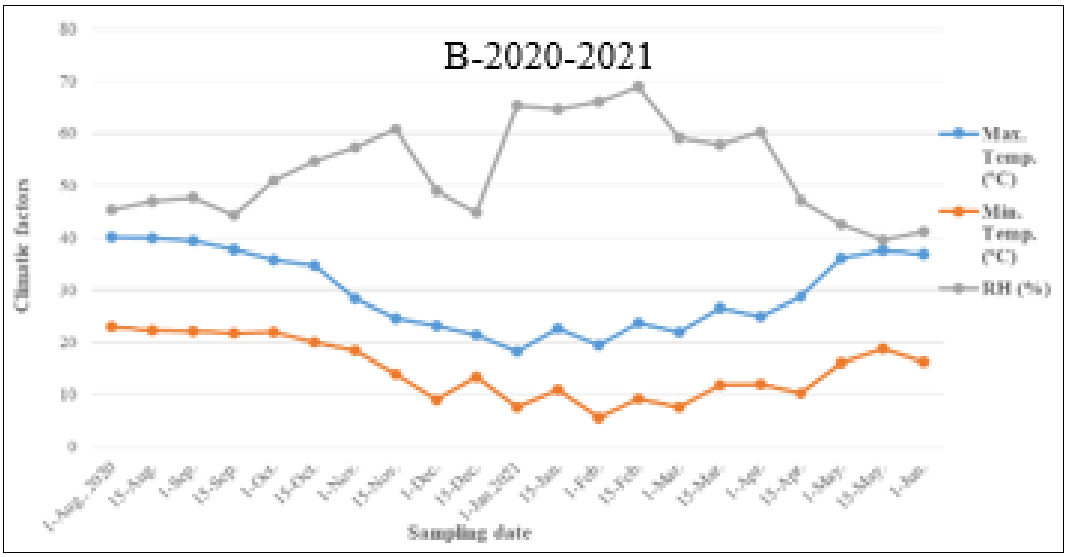


Fig (3 a&b): Seasonal fluctuation of *P. solenopsis* Tinsley population in response to max., min. temperature and relative humidity on *Physalis peruviana* L. at Benha locality, Qalyubiya Governorate during two years of 2019-2020&2020-2021

Table 4: Approximate number and durations of annual generations of *Phenacoccus solenopsis* Tinsley on *Physalis peruviana* L. at Benha locality, Qalyubiya Governorate during two seasons 2019-2020 to 2020-2021.

No. of generation	2019-2020 2020-2021					
	Approximate date of Duration occurrence			Approximate date of Duration occurrence		
	From	To	In days	From	To	In days
First	1 Aug.	15 Oct.	75	1 Aug.	1-Nov.	90
Second	1 Nov.	15-Apr.	165	15- Nov.	1-Apr.	165
Third	1-May.	15-Jul.	105	15-Apr.	15-Jul.	105

Table 5a: Statistical analysis based on correlation coefficient and multiple regression indicating the effects of climatic factors on different stages of *Phenacoccus solenopsis Physalis peruviana* L. at Benha locality, Qalyubiya Governorate during two seasons 2019-2020

Factors	Level	Simple correlation	Multi Regression				F	E.V.%
		r	b	S.E.	t	p		
Weather	Max. Temp.	0.815252	18.14342	26.86886	0.701311	0.49119	29.53379 31.59	81.59
	Min. Temp	0.89 5666	109.3991	30.47983	3.589228	0.001834		
	R.H.%	-0. 52302	14.94089	12.27958	1.216727	0.237872		
Namral enemies	*Hyperaspis vincigerrae* Capra	0.888296	2173803	5.452575	4.170146	0.00052	24.51845	83.77
	Chrysoperla carnea (Stepd)	0.812252	33.29732	15.50717	2.147221	0.044893		
	Nephus hiekei Furch	0.548425	_18061	19.00005	-0.95058	0.353755		
	Orius albidipennis Reuter	0.654646	.0.02649	16.74099	-0.00158	0.998754		
	Dicrodiplosis manihoti Harris	0.52854	11.04638	7.937680	0.581204	0.558712		
All factors	.	-	-	-	-	-	31.5754	56.92

Table 5b: Statistical analysis based on correlation coefficient and multiple regression indicating the effects of climatic factors on different stages of *Phenacoccus solenopsis* on *Physalis peruviana* L. at Benha locality, Qalyubiya Governorate during two seasons 2020-2021

Factors	Level	Simple correlation	Mult i Regression				F	E.V. %
		r	b	S.F.	t	p		
Weather	Max. Temp.	0.793972	32.60815	47.28327	0.689634	0.498349	13.32	66.66
	Min. Temp	0.810433	73.45244	53.49243	1.373137	0.18491		
	R.H.%	.025213	0.282133	15.37206	0.018354	0.985539		
Natural enemies	*Hyperaspis vincigerrae* Capra	0.932095	31.50205	4.94537	6.370007	4.13E-06	37.35	88.72
	Chrysoperla carnea (Stepd)	0.796465	.0.92067	10.7725	.0.08546	0.932786		
	Nephus hiekei Furch	0.454456	.34.6363	14.68905	.2.35797	0.029246		
	Orius albidipennis Reuter	0.305651	3.852276	15.66102	0.245979	0.808337		
	Dicrodiplosis manihoti Harris	0.323437	2.60639	9.78654	0.487650	0.610286		
All factors		-	-		-	-	16.29	77.43

Table 6: Percentages of reduction of *P. solenopsis* Tinsley infesting Cape gooseberry plants at on *Physalis peruviana* L. at Benha locality, Qalyubiya Governorate during two seasons 2019-2020 to 2020-2021.

Treatments	Rate of application	First season (2019-2020)				Second season (2020-2021)			
		% Reduction of *P. solenopsis* Tinsley				%Reduction of *P. solenopsis* Tinsley			
		Nymphs	Adult female	Gravid females	Total	Nymphs	Adult female	Gravid females	Total
Super Oil	1.5 L/100 L water	88.40	80.97	74.17	81.18[a]	84.54	79.09	69.62	77.75[a]
Jojoba Oil	300 cm/100 L water	82.56	75.39	64.18	74.04[b]	80.29	71.58	61.16	71.01[b]
Saflon	200 cm /100 L water	68.03	56.11	50.27	58.13[c]	60.0	50.88	45.0	51.96[c]
F value		5.36*				11.45*			
L.S.D at 0.05%		1.026				2.36			

Mean in each column not followed by the same letter are significantly different $p<0.05$

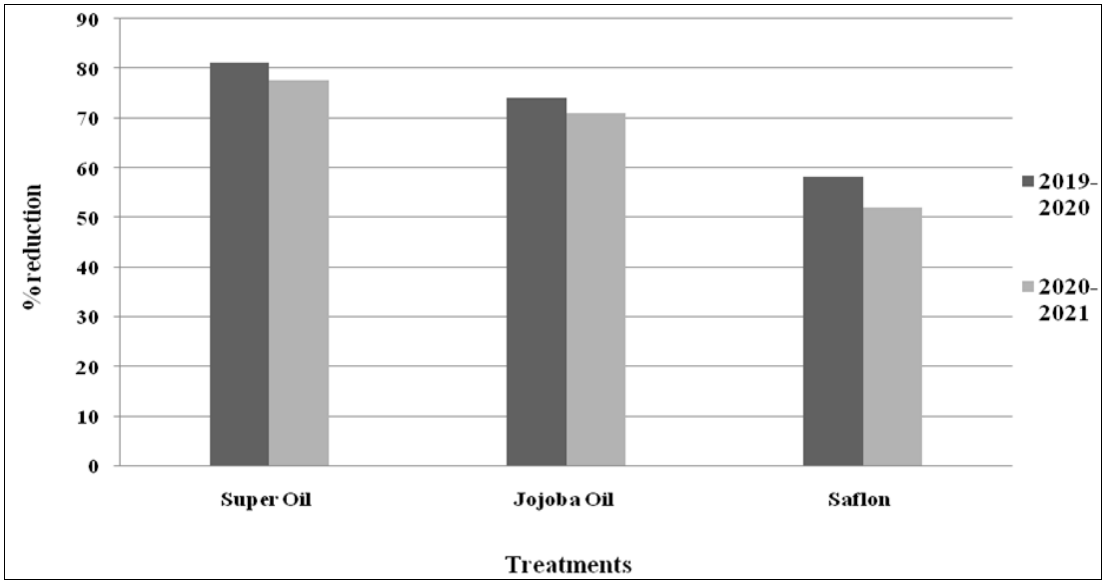


Fig 4: Percentages of reduction of *P. solenopsis* Tinsley infesting goldenberry plant, *Physalis peruviana* L. at Benha locality, Qalyubiya Governorate during two seasons 2019-2020 to 2020-2021

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