Population Dynamics and Chemical Control of Two Diaspid Scales Infesting Mango Trees

Adnan Abdel-Fattah El-Sayed Darwish

Plant protection department, Faculty of Agriculture, Damanhour University, Egypt adnandarwish2012@yahoo.com adnan.darwish@agr.dmu.edu.eg

DOI: 10.21608/JALEXU.2021.92468.1002

Article Information

Received: August 25th 2021

Revised: August 26th 2021

Accepted: September 8th 2021

Published: September 9th 2021

ABSTRACT: In the present work, an effort was made to study some ecological aspects and chemical control of two diaspid scales, ie, white mango scale, *Aulacaspis tubercularis* Newstead and olive parlatoria scale, *Parlatoria oleae* (Colvee) (Hemiptera: Diaspididae) on mango trees in Nobaria district, Beheira governorate, Egypt. The study lasted for two years from the beginning of 2019 to the end of 2020. The results showed that the total population of the white mango scale recorded three peaks on mango trees. The three peaks occurred on January 15th, March 12th and September 17th throughout the 1st year, 2019. In the consecutive year, 2020 such three peaks were recorded on January 21st, March 31st and September 22nd. The mango leaves at the middle stratum and the east direction were the most preferred leaves by *A. tubercularis*. On the other hand, three peaks were recorded by *P. oleae* on March 26th, May 21st and October 8th during the first year, and on March 17th, June 19th and September 29th during the 2nd year. The leaves at the lower stratum and the tree core were the most preferred leaves by *P. oleae*. Both scale species significantly preferred the upper surface of mango leaves to the lower one. The efficacy of four insecticides, ie, botanical insecticide, mineral oil, IGR and neonicotinoid insecticide for controlling the two scales were estimated to ensure that acetamiprid was the highly effective insecticide against *A. tubercularis*, and pyriproxyfen was the highly effective one for *P. oleae*. *A. tubercularis* was more tolerant to the tested insecticides than *P. oleae*.

Keywords: Mango, *Aulacaspis tubercularis*, *Parlatoria oleae*, Ecological aspects, Acetamiprid, Pyriproxyfen, Azadirachtin, K.Z oil

INTRODUCTION

Mango, *Mangifera indica* (L.), fam. Anacardiaceae, is considered to be one of the most important fruit trees in the world, including Egypt. The total cultivated area in Egypt is about 187730 Fed. with a total annual production of 850114 metric tons (Food and Agriculture Organization of the United Nation, 2020). As many tropical and subtropical crops, many species of insects and mites have been reported to infest mango trees such as the scale insects (Hemiptera: Sternorrhyncha: Coccoidea). Worldwide, the scale insects are key pests on ornamental plants and fruit trees. The three most important families of the scale insects, according to the economic damage and number of genera, are Coccidae (soft scales) with 170 genera, Pseudococcidae (mealybugs) with 272 genera and Diaspididae (armored scales) with 419 genera (García Morales, *et al.*, 2016). Diaspid scales can cause economic damage directly with its piercing and sucking mouth parts; through sucking the sap from the leaves, twigs and fruits; the transmission of viruses; and the injection of toxins into the plants, which weaken the plant and lower the fruit yield and quality (Waite, 2002; Sathe, *et al*. 2014; Hassan, *et al*., 2012; Ouvrard, *et al*., 2013; Darwish, 2015 and Darwish, 2020). The mango white scale, *Aulacaspis tubercularis* (Newstead) is one of the most dominant armored scale insects in mango orchards (El–Metwally, *et al*., 2011; Reda, *et al*., 2011; Abo-Shanab, *et al*., 2012; Ayalew, 2015; Hamdy, 2016; Pino, 2020 and Lo Verde, *et al*., 2020). The first record of *A. tubercularis* as a new pest of mango trees in Egypt was in Minia governorate (Morsi *et al*., 2002). Thereafter, the insect has been distributed allover the governorates of Egypt. If no control measures were performed**,** the mango white scale can cause yield losses up to ninety percent in mango groves (Pino, *et al*., 2020). The olive scale, *Parlatoria oleae* (Colvée) is another important scale insect infesting mango trees (Bakry, *et al.*, 2019 and Bakry, *et al.*, 2020). Both the nymphs and the adults of *P. oleae* are the damaging stages. Heavy infestations with *P. oleae* on leaves and branches of the fruit trees cause extensive die-back and yield losses. The injection of toxins into the plants by the stages of *P. oleae* causes dark-red spots on fruits, branches and leaves of its hosts. It was emphasized that the first step towards the progress of the integrated pest management program of any insect pest is the extensive ecological study of this pest (Hassan and Radwan, 2008). Therefore, to select and schedule appropriate control strategies, growers should use the information gathered from the field monitoring/scouting of the insect pests. We also have to take into account the fact that the updated survey of the scale insect pests is very required because most scale insects are sensitive to the changes in the meteorological factors, the host preference and the agriculture practices. Chemical control has been considered to be the most important tool employed for the management of scale insects, particularly when the other control measures are not sufficient to prevent plant injury. Keeping in view the above-mentioned facts, the present work was designed to study some ecological aspects and chemical control of two diaspid scales infesting mango trees during two successive years (2019 and 2020) in Behiera governorate.

MATERIALS AND METHODS

Some ecological aspects of *A. tubercularis* and *P. oleae* on mango trees

The present experiments were conducted at a private mango farm in Nobaria district, Beheira governorate, Egypt. Twelve years old Ewais mango trees were used in this study. The trees were grown in sandy soil under drip irrigation system, spaced at 6 X 4 m apart. The study period extended from the beginning of 2019 until the end of 2020, ie, two consecutive years. Ten mango trees homogenous in size and age were chosen and marked for sampling purposes. The selected trees were infested by some diaspids scale insects including *A. tubercularis* and *P. oleae*. Regular weekly samples represented the four cardinal directions (south, north, west, and east) as well as the tree core and the three tree strata. The sample consisted of seventy five leaves (15 leaves/ tree) of five mango trees, from the selected trees. The different stages of the two scale insects on the different mango leaf surfaces were accurately counted and recorded. The picked leaves were kept in 15 polyethylene bags; each bag represents a specific direction or a particular layer of the tree. Samples were transported to the laboratory, and inspected carefully with the aid of a stereomicroscope. Throughout the study period, except the application of any insecticides, all recommended agriculture practices were performed as usual. The monthly variation rate (MVR) in population density was calculated by dividing the average count given in a month by the average count given in the preceding one (Abdel-Fattah *et al*, 1978).

Fruit samples

Twenty five fruits on mango trees, or those dropping on the soil, were collected within 8 weeks' time during the fruit ripping period to study the relative fruit susceptibility to infestation with the two scale insects, *A. tubercularis* and *P. oleae*.

Effect of four different insecticides on the population density of *A. tubercularis* and *P. oleae*

Field experiments were carried out to evaluate the effect of four insecticides on the population density of *A. tubercularis* and *P. oleae*. Five treatments, four insecticides and control, were applied using a randomized complete block design (CRBD). The treatments were replicated five times with one tree per replicate making a total of 25 mango trees homogenous in size, age, height, and vigor. Before the start of the experiment, the experimental units, ie, trees, were not treated with any insecticide. The tested compounds were sprayed on April 25th in both seasons at their label recommended rates with complete coverage of all parts of the treated trees. A Knapsack sprayer, CP3 was used for spraying the different insecticides. The control plots were sprayed only with water. Randomly, five mango leaves of each tree (25 leaves from each treatment) were picked and kept in paper bags for the further examination in the laboratory. The total population of *A. tubercularis* and *P. oleae* were recorded just before spraying with insecticides and after one, two, three and four weeks. The reduction percentages of *A. tubercularis* and *P. oleae* were calculated according to the Henderson and Tilton (1955) equation as follows:

Corrected % = (1 –((ncb*nta)/(nca*ntb)))*100

Where:

nta = mean numbers of scale insects in treatment after application

ncb = mean number of scale insects in control before application

ntb = mean number of scale insects in treatment before application

nca = mean number of scale insects in control after application

The tested insecticides and their usage doses

Admiral® (Pyriproxyfen 10% EC): formulated by Sumitomo Chemical Co. Ltd., used at the rate of 50 ml / 100 L water

Nimbecidine® (Azadirachtin 0.03% EC): formulated by T. Stanes and Company Limited, used at the rate of 500 Cm^3 / 100 L water

K.Z oil®: In Miscible type formulated by Kafr El-Zayat Co., used at the rate of 1.5 L / 100 L water.

Mospilan® (Acetamiprid 20% SP): formulated by Nisso Co., used at the rate of 30 g/100 L water

RESULTS AND DISCUSSION

The white mango scale, *A. tubercularis*

Seasonal fluctuation of different developmental stages of the white mango scale, *A. tubercularis*

The seasonal fluctuation of *A. tubercularis* which represented by weekly mean numbers of immature and adult stages throughout two successive years are graphically illustrated in Figs. 1 and 2. The results showed that the population density of *A. tubercularis* was higher during the 2nd year, 2020, than in the 1st year, 2019. Three population peaks occurred in January 15th, March 12th and September 17th throughout the first year, 2019, with average values of 46.93, 54.4 and 91.47 individuals/ leaf, respectively. In the consecutive growing year, 2020, such three peaks were recorded on January 21st (89.87 individuals/ leaf), March 31st (88 individuals/ leaf) and September 22nd (108.53 individuals/ leaf). The results also showed that the population density of the adult stage was less than that of the immature stages. From the current results, it's obvious that the white mango scale has three peaks per year ie, three overlapping generations. The present results are slightly different from the results of Kawiz, 2009, Hamdy, 2016 and Amer *et al.*, 2017 in Qaliobiya governorate and Lo Verde, *et al.*, 2020 in Southern Spain who recorded four peaks for this insect. On the other hand, Attia, *et al.*, 2020 in Sharkia governorate found that the total alive stages population of *A. tubercularis* had two activity peaks during two successive years of study.

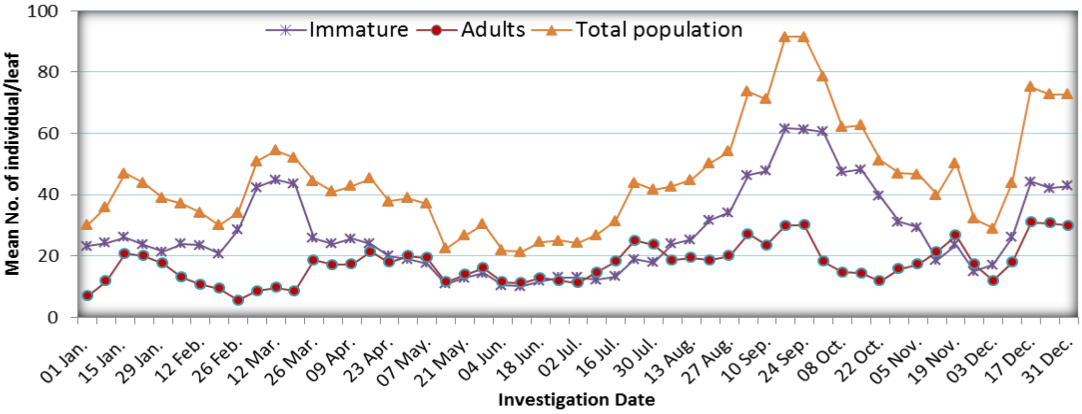


Fig (1): Seasonal fluctuations of immature and adult stages of the white mango scale, *Aulacaspis tubercularis* represented by weekly means/leaf, on mango trees during 2019 year.

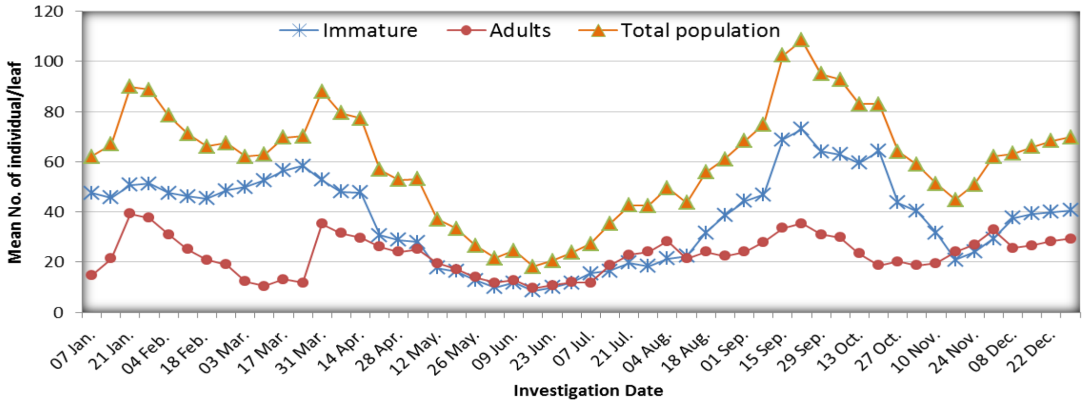
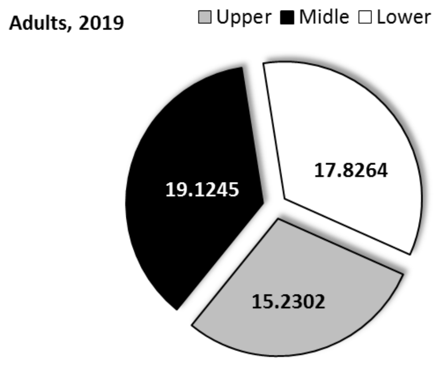


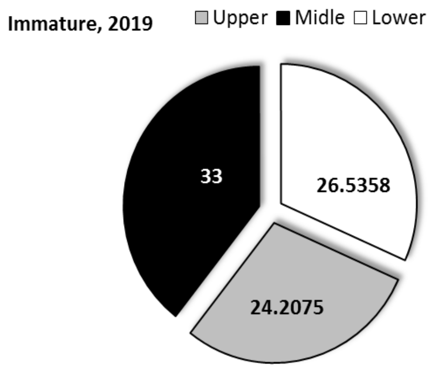
Fig (2): Seasonal fluctuations of immature and adult stages of the white mango scale, *Aulacaspis tubercularis* represented by weekly means/leaf, on mango trees during 2020 year.

The vertical distribution of *A. tubercularis*

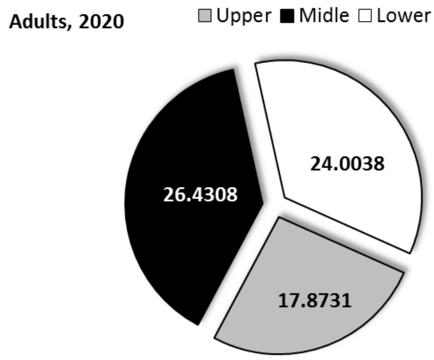
Data in Fig. 3 revealed that the distribution pattern of *A. tubercularis* significantly varies according to the levels of mango trees. During the 1st season, the middle stratum of mango trees always harbored the highest population density of the adult stage, with a general mean of 19.12 adults/ leaf. The lowest population density, with a general mean of 15.23 adult /leaf, was recorded in the upper stratum. The results also showed that the middle level of mango trees always harbored the highest population density of immature stage of *A. tubercularis*, 33 individuals /leaf, followed by the lower level, 26.54 individuals /leaf, and the upper level, 24.21 individuals /leaf. As shown in Fig. 3, the results obtained in the 2nd season, 2020, revealed that the upper stratum of the mango trees was the least preferable stratum for both adults and immature stages of *A. tubercularis* followed by the lower and the middle stratums. The present results support the results of Bakry and Eman, 2019 who found that the white mango scale prefers the middle stratum of the mango trees in Esna District, Luxor governorate, Egypt. On the contrary, Nabil *et al*. (2012) reported that the infestation with the same insect, *A. tubercularis*, at the bottom stratum of the mango trees was higher than that at the top one in Sharkia governorate, Egypt.



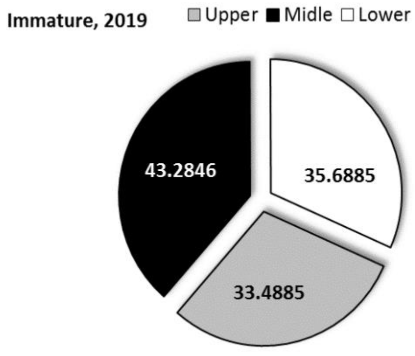
n=53, F= 4.470, L.S.D.= 2.62



n=53, F= 5.456, L.S.D.= 5.448



n=52, F= 14.799, L.S.D.= 3.2031



n=52, F= 4.26, L.S.D.= 6.95

Fig. 3. Seasonal mean numbers of *A. tubercularis*, adults and immature stages, in the different strata of mango trees through two successive years (2019 and 2020)

The horizontal distribution of *A. tubercularis*

Data shown in Fig. 4 emphasize that population distribution pattern of *A. tubercularis* considerably differs from one direction to another. The mango leaves at eastern direction harbored the maximum average numbers of *A. tubercularis* immature, 36.85 and 48.75 individuals/leaf in 2019 and 2020, respectively; and adult stages,19.98 and 28.46 adults/leaf in 2019 and 2020, respectively. South direction ranked the second with a seasonal mean of 29.58 and 41.66 immature individuals/leaf, and 18.98 and 23.86 adult individuals / leaf throughout the 1st and 2nd seasons, respectively followed by tree core, 28.25 and 37.26 immature individuals/ leaf, and 16.36 and 22.92 adults/leaf in 2019 and 2020, respectively. The lowest average numbers were recorded in the western direction,21.59 and 26.1 immature individuals/ leaf, and 17.78 and 19.14 adult/leaf in 2019 and 2020, respectively. The current results are in agreement with the results of Nabil *et al*. (2012) who mentioned that the white mango scale are concentrated in the eastern direction than the other directions. In close results, El-Metwally *et al*. (2011) found that the southern direction was the most preferable direction for *A. tubercularis* followed by the eastern direction.

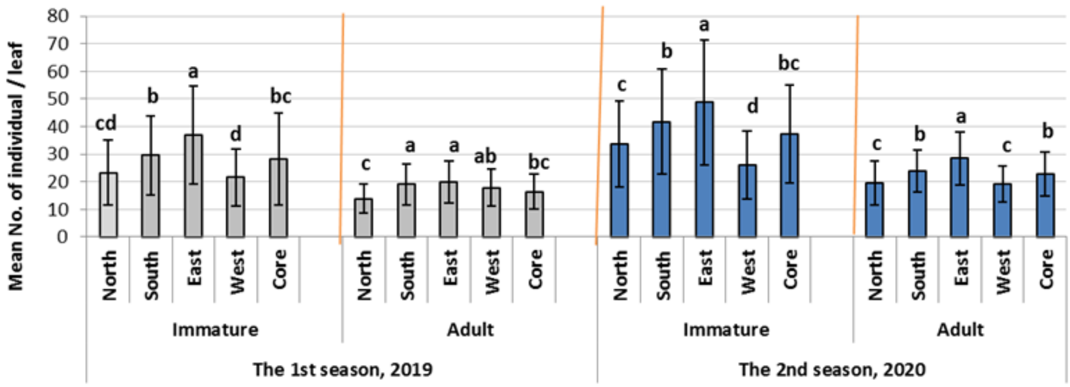


Fig. 4. The horizontal distribution of *A. tubercularis* (adults and immature stages) in the main cardinal directions and mango tree core through two successive years (2019 and 2020). The bars followed by the same letter(s) in the column are not significantly different (P< 0.05)

.

Distribution of *A. tubercularis* on different leaf surfaces

Results depicted in Fig. 5 clearly indicated that the adult and immature stages of *A. tubercularis* prefer the upper surface of the mango leaves to the lower surface. The seasonal mean numbers of the immature stage of the white mango scale per leaf on the lower surface were 5.55 ± 2.37 and 12.56 ± 6.7 for the two years of study, 2019 and 2020, respectively. These means on the upper surface were 22.36±11.83 and 24.92 ±10.91 individuals/leaf, in 2019 and 2020, respectively. Regarding the distribution of adults of this insect on the upper and the lower surfaces of mango leaves, the results showed that high population densities of adults of *A. tubercularis* were recorded in the upper surface 9.23±3.9 and 13.82±5.73 in 2019 and 2020, than the lower surface, 8.16±2.94 and 8.95±2.35 in 2019 and 2020.

The current results are in agreement with the results of Bakr *et al.* (2009), Nabil *et al*. (2012), Sanad (2017) and Bakry and Eman, 2019 who found that the white mango scale prefers the upper surface of mango leaves to the lower one. Other results were obtained by El-Metwally *et al.*, 2011 who found that the white mango scale prefers the upper surface in winter months, whereas in the summer months they prefer the lower surface. The statistical difference between the population density in the upper and the lower surfaces was more pronounced for immature stage (t= 12.349 for 1st year, 2019; t= 18.658 for the 2nd year, 2020) than it's in the case of adult stage (t= 3.086 for 1st year, 2019; t= 8.795 for the 2nd year, 2020)

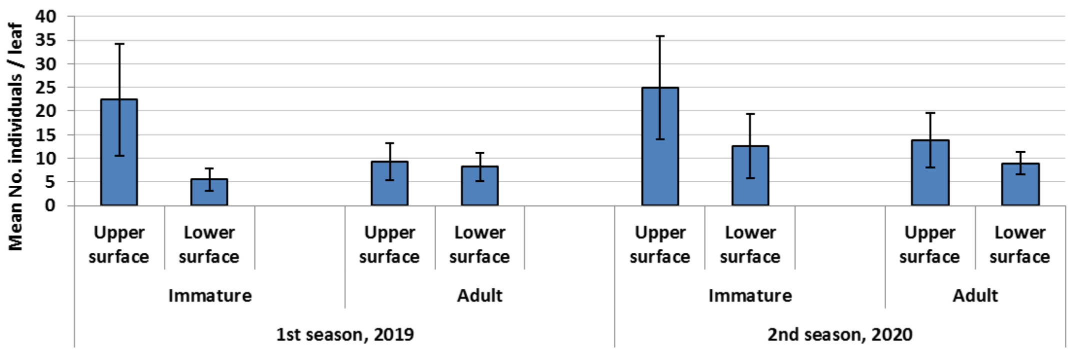


Fig. 5. Seasonal mean numbers of *A. tubercularis* (adults and immature stages) in the different surfaces of mango leaves through two successive years (2019 and 2020)

The Olive Parlatoria, *Parlatoria Olea* (Colvée)

Seasonal fluctuation of different developmental stages of the olive parlatoria, *P. Olea*

During the 1st season, 2019, as shown in Fig. 6, the population density of *P. oleae* started with relatively low numbers and then increased gradually till reaching the first abundance peak on March 26th,13.6 individuals/leaf. The 2nd peak, the highest peak, was recorded on the May 21st, 14 individuals/ leaf. Afterwards, the population decreased and fluctuated throughout the period from May to September. Then it increased again to reach the 3rd peak on October 8th, 12.53 individuals/leaf. During the 2nd season, 2020, a similar trend was obtained (Fig. 7), whereas the 1st

peak, the highest peak, was recorded on March 17th, 21.87 individuals/leaf. The 2nd and the 3rd peaks were recorded on June 19th and September 29th with a mean of 19.73 and 17.07 individuals/leaf, respectively. Similar results were obtained by Moursi, *et al*., 2013 who found that the population of olive parlatoria scale reached the maximum density during April, November and January in 2010, but in 2011 the insect had four peaks during March, August, November and January on plum trees in Burg El-Arab area, Egypt.

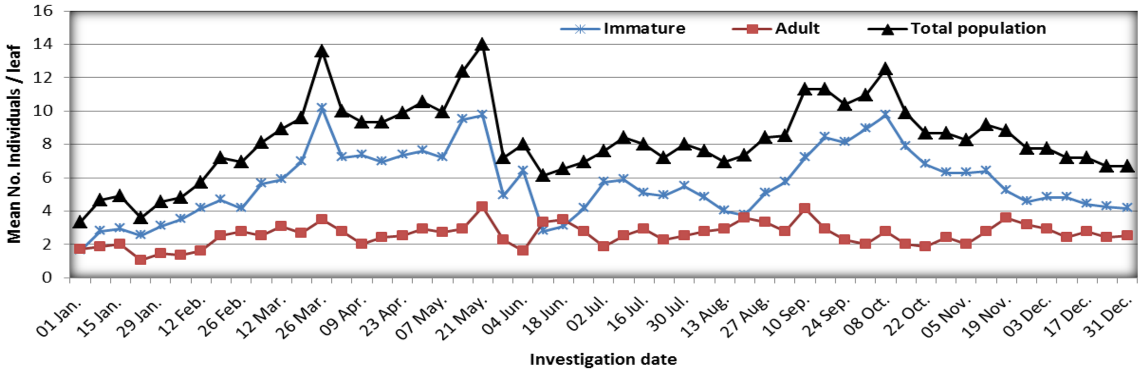


Fig (6): Seasonal fluctuations of immature and adult stages of the olive parlatoria, *Parlatoria oleae* represented by weekly means/leaf, on mango trees during 2019 year.

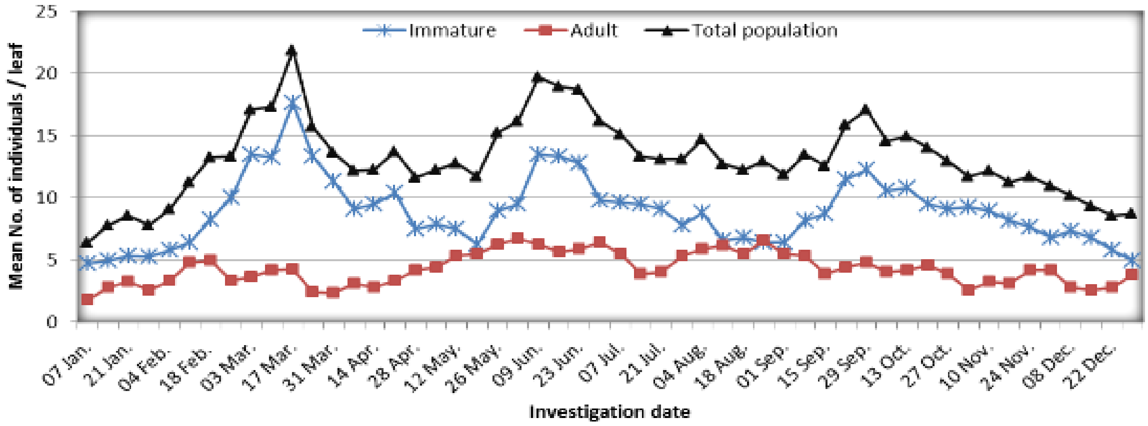


Fig (7): Seasonal fluctuations of immature and adult stages of the olive parlatoria, *Parlatoria oleae* represented by weekly means/leaf, on mango trees during 2020 year.

The Vertical distribution of *P. Oleae*

The data obtained in Fig. 8 showed that the highest population density of *P. oleae* was found on leaves at the bottom level of mango trees, followed dissentingly by the population density on leaves at middle and top levels of the tree. The seasonal mean of immature population densities at the bottom level recorded 6.71± 2.38 and 11.91 ± 3.36 per leaf during the 1st and the 2nd seasons, respectively. While the population densities of adult stages were 3.08 ± 1.11 and 5.39 ± 1.52 adults per leaf through the two successive years 2019 and 2020, respectively. Regarding the tree middle level, the seasonal means of adults and immature stages were 2.91 ± 0.75 and 6.3±2.61 during the 1st season and 4.46±1.59 and 8.36 ± 2.88 during the 2nd season, respectively. The leaves of the lower stratum of mango tree had the lowest population density of *P. oleae*, whereas the adults and immature densities were 1.77±0.53 and 4.01±1.5 in the 1st season and 2.89±0.98 and 6.37±2.19 individual/leaf during the 2nd season. The present results are in harmony with the results of Bakry, *et al.*, 2019 who found significant differences between the mean population densities of *P. oleae* on different levels of mango trees.

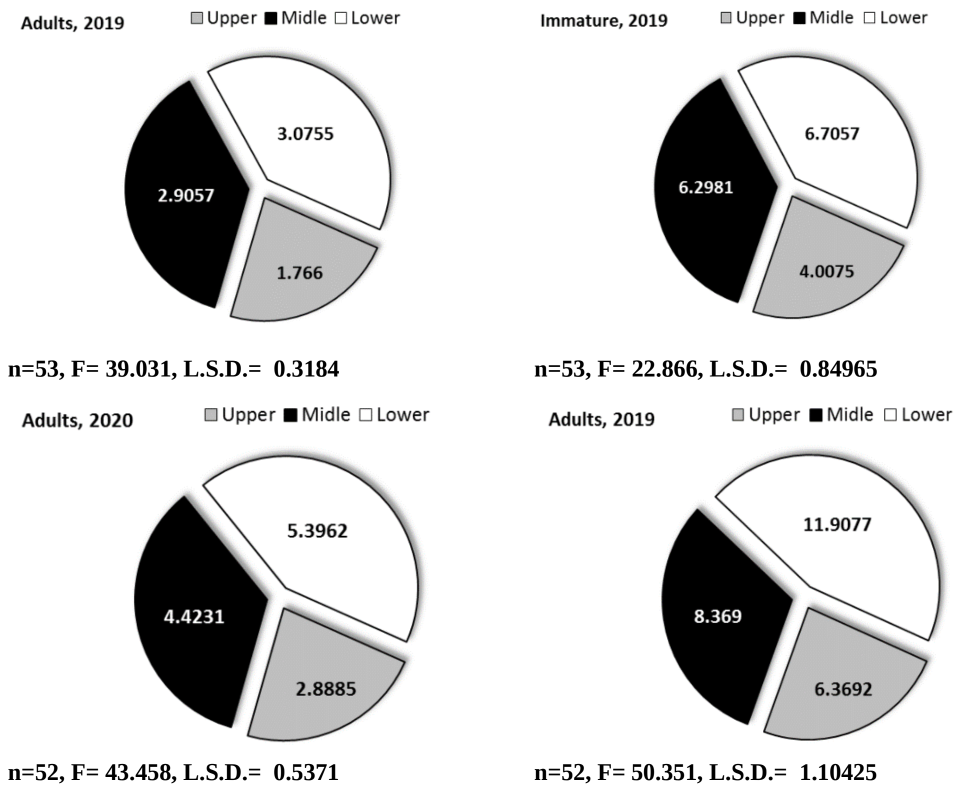


Fig. 8. Seasonal mean numbers of *A. tubercularis* (adults and immature stages) in the different strata of mango trees through two successive years (2019 and 2020)

The Horizontal distribution of *P. oleae*

As illustrated in Fig. 9, the leaves at mango tree core harbored the maximum population of *P. oleae* immature, 23.23 and 31.73 individuals/leaf in 2019 and 2020, respectively, and adult stages,9.64 and 15.02 adults/leaf in 2019 and 2020, respectively. South direction ranked the second with a seasonal mean of 18.6 and 29.52 immature individuals/leaf and 7.81 and 13.71 adult individuals /leaf throughout the 1st and the 2nd seasons, respectively followed by the east direction, 17.02 and 26.4 immature individuals/leaf and 8.52 and 13.08 adults/leaf in 2019 and 2020, respectively. The lowest average numbers were recorded in the northern direction, 12.77 and 21.08 immature individuals/leaf and 7.08 and 11.98 adult/leaf in 2019 and 2020, respectively.

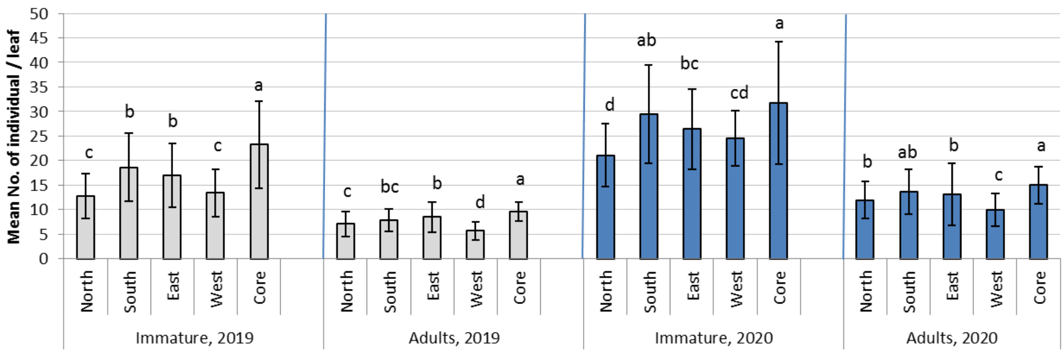


Fig. 9. The horizontal distribution of *P. oleae* (adults and immature stages) in the main cardinal directions and mango trees core through two successive years (2019 and 2020). The bars followed by the same letter(s) in the column are not significantly different (P< 0.05).

Distribution of *P. oleae* on different leaf surfaces

The data illustrated in Fig. 10 showed that the adult and immature stages of *P. oleae* prefer the upper surface of the mango leaves to the lower surface. The general means of the immature stage on the lower surface were 2.22 ± 0.89 and 3.65 ± 1.24/ leaf for 2019 and 2020, respectively, whereas the general immature means on the upper surface were 3.46 ±1.24 and 5.23 ±1.65/leaf, in 2019 and 2020, respectively. The population density of *P. oleae* adults on the upper and lower surfaces of mango leaves recorded 1.33 ± 0.43 and 1.25 ± 0.41 during 2019 season, whereas these values in the 2nd season, 2020 were 2.41 ±0.71 and 1.84 ±0.7 on the upper and the lower surfaces, respectively. The present results support the results of Bakry, *et al.*, 2019 who found that the total population of *P. oleae* was more abundant on the upper surface than on the lower one.

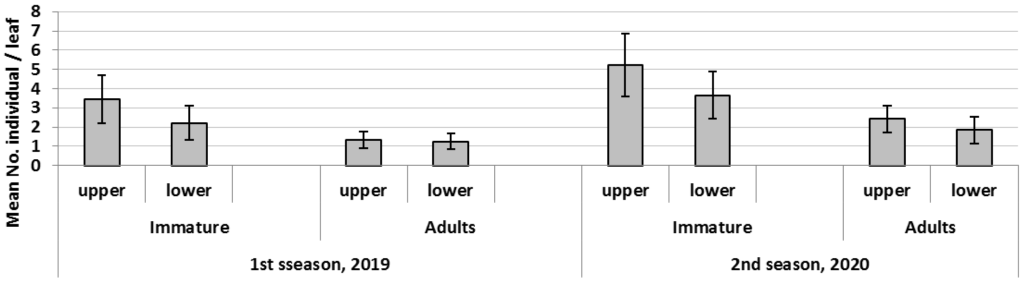


Fig. 5. Seasonal mean numbers of *P. oleae* (adults and immature stages) in the different surfaces of mango leaves through two successive years (2019 and 2020)

The relative susceptibility of mango fruits to infestation with both of *P. olea* and *A. tubercularis*

Despite the obvious increase in the population density of the white mango scale compared with the parlatoria scale as shown in Figs. (1, 2, 6 and 7), the study of the population density of the two scales on mango fruits shows that the olive parlartoria scale is present more abundantly than white mango scale. This result suggests that the parlatoria scale might be more dangerous than the white mango scale.

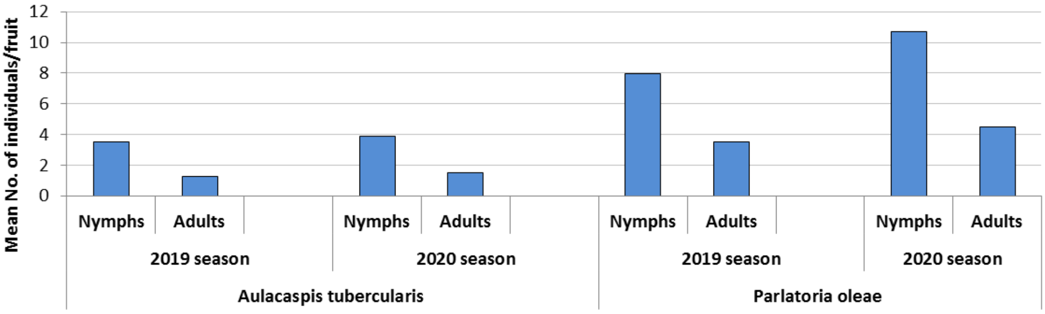


Fig. 10. The relative susceptibility of mango fruits to infestation with *P. oleae* and *A. tubercularis* (adults and immature stages) through two successive years (2019 and 2020)

The Monthly variation rate (MVR) of population density of *A. tubercularis* and *P. oleae*

The monthly counts of the total population of *A. tubercularis* and *P. oleae* through the two successive years of investigation are tabulated in Table 1. Data concerning the monthly variation rate (MVR) of population density of *A. tubercularis* clearly show that the favorable periods for its development and population increase were in March and September 2019, with MVR values of 1.49 and 1.71, respectively (Table 1). In the second year, 2020, the highest values of MVR were 1.309, 1.698 and 1.71 in January, July and September, respectively. On the other hand,

the highest monthly variation rates (MVR) of population density of *P. oleae* were 1.46, 1.48 and 1.374 in February, March and September in the 1st year, 2019, and 1.539, 1.463 and 1.378 in February, March and June in the 2nd year, 2020, respectively

Table (1): The monthly variation rate (MVR) of population density of *A. tubercularis* and *P. oleae* during two successive seasons, 2019 and 2020

Months	*A. tubercularis*				*P. oleae*			
	2019		2020		2019		2020	
	Total population	MVR	Total population	MVR	Total population	MVR	Total population	MVR
January	39.15	-	76.93	1.309	4.21	-	7.6	1.07
February	33.87	0.865	70.8	0.92	6.17	1.46	11.7	1.539
March	50.47	1.49	70.56	0.997	9.13	1.48	17.12	1.463
April	41.23	0.817	66.6	0.944	10.93	1.197	12.433	0.726
May	29.13	0.713	37.53	0.564	8.97	0.82	13	1.046
June	23.2	0.796	21.71	0.578	7.167	0.799	17.92	1.378
July	33.65	1.444	36.87	1.698	7.84	1.09	13.63	0.761
August	48	1.426	52.53	1.425	7.567	0.965	13.13	0.963
September	81.93	1.71	89.81	1.71	10.4	1.374	13.73	1.046
October	60.32	0.736	80.67	0.898	10.13	0.97	14.3	1.041
November	42.33	0.702	51.47	0.64	8.5	0.839	11.7	0.818
December	58.77	1.388	65.87	1.28	7.093	0.835	9.52	0.814

Effect of four insecticides on *A. tubercularis* and *P. oleae*

Based on data presented in Tables (2&3), it is evident that during the 1st season, 2019, acetamiprid was the highly effective insecticide against *A. tubercularis*, with a general mean of 87.87% reduction percentage, followed by pyriproxyfen 84.56 %, azadirachtin 78.01 % and KZ oil 69.1 % with significant difference between the efficacy of the tested insecticides on the total population of *A. tubercularis*. The same results were obtained during the 2nd season, whereas the descending order of the tested insecticides was acetamiprid 90.37 %, pyriproxyfen 84.55 %, azadirachtin 81.25 % and K.Z oil 67.26 %. The two tested insecticides acetamiprid and pyriproxyfen, during the 1st season, and pyriproxyfen and azadirachtin, during the 2nd season, had insignificant differences between each one of them with the other where L.S.D. was 6.2106 and 5.4696 during the two consecutive seasons 2019 and 2020, respectively. Regarding the susceptibility of *P. olea* to the tested insecticides (Tables 4 and 5), it's obvious that the olive scale was more resistant to the tested insecticides than the white mango scale. The insecticide pyriproxyfen was the highly effective insecticide against the insect with general means of 76.77 % and 77.57 % in 2019 and 2020 seasons, respectively. The insecticide, acetamiprid ranked the second with general means of 75.19 % and 69.97 %, followed by azadirachtin with general means of 66.59 % and 62.85 %, and finally K Z oil with general means of 65.08 and 61.97 in 2019 and 2020 seasons, respectively.

The current results revealed that the tested insecticides were more effective than the K.Z oil in disagreement with the results of Dewer, *et al*., 2012 who studied the effect of five insecticides, i.e., azadirachtin, pyriproxyfen, acetamiprid, emamectin benzoate and summer mineral oil and their mixtures for controlling *Lepidosaphes beckii*. They found that the use of summer mineral oil gave the highest reduction percentages. In agreements with Baker, *et al*., 2012 the reduction percentages of the insecticide pyriproxyfen (IGRS) still to increase and gave high effect till the end of the experiment. Mohamed, 2002 found that the red scale insect, *A. aurantii* was affected by pyriproxyfen than K.Z oil. Mohamed (2002) tested fenitrothion, pyriproxyfen, mineral oil 94% E C on *P. oleae* in Ismailia; he found that oil alone or mixed with other compounds held superior category allover the experiment time.

Table (2): Reduction percentages of the white mango scale, *A. tubercularis* induced by application of four insecticides on mango trees during the 1st season, 2019

Insecticides	Weeks post treatment				General mean
	1 week	2 weeks	3 weeks	4 weeks	
Nimbecidine®	64.22±5.89^{bc}	87.79±2.34^{b}	80.48±8.04^{c}	79.54±6.64^{a}	78.01±10.43^{b}
Mospilan®	78.45±7.7^{a}	94.59±3.41^{a}	88.84±3.22^{a}	89.59±3.19^{a}	87.87±7.45^{a}
Admiral®	76.63±5.65^{ab}	84.62±8.57^{b}	90.44±2.07^{a}	86.57±2.15^{a}	84.56±7.12^{a}
K.Z oil®	56.82±12.74^{c}	74.71±6.61^{c}	80.92±2.63^{c}	63.95±13.32^{c}	69.1±13.19^{c}
F value	13.178	10.042	5.923	5.954	14.093
L.S.D.	13.1779	6.41315	7.165	13.2438	6.2106

The reduction percentages followed by the same letter(s) in the column are not significantly different (P< 0.05).

Table (3): Reduction percentages of the white mango scale, *A. tubercularis* induced by application of four insecticides on mango trees during the 2nd season, 2020

Insecticides	Weeks post treatment				General mean
	1 week	2 weeks	3 weeks	4 weeks	
Nimbecidine®	79.37±6.88[a]	82.15±5.55[b]	82.66±8.48b[c]	80.8±7.79[a]	81.25±6.79[b]
Mospilan®	83.4±4.43[a]	97.8±3.41[a]	94.68±3.41[a]	85.59±5.91[a]	90.37±7.39[a]
Admiral®	69.93±7.11[b]	93.86±2.52[a]	89.78±2.87[ab]	84.62±1.79[a]	84.55±10.03[b]
K.Z oil®	64.23±6.39[b]	65.77±9.06[c]	77.17±8.31[c]	61.86±10.56[b]	67.26±10.02[c]
F value	9.645	31.595	7.415	11.725	25.573
L.S.D.	8.43375	7.6705	8.4989	9.72145	5.4696

The reduction percentages followed by the same letter(s) in the column are not significantly different (P< 0.05).

Table (4): Reduction percentages of the olive scale, P. olea induced by application of four insecticides on mango trees during the 1st season, 2019

Insecticides	Weeks post treatment				General mean
	1 week	2 weeks	3 weeks	4 weeks	
Nimbecidine®	61.41±5.12[ab]	69.48±8.21[b]	71.34±8.75[b]	64.14±7.93[bc]	66.59±8.11[b]
Mospilan®	56.55±10.27[b]	85.97±6.73[a]	83.9±7.32[a]	74.33±4.14[a]	75.19±13.74[a]
Admiral®	67.07±8.27[a]	86.32±6.51[a]	83.61±4.55[a]	70.07±6.97[ab]	76.77±10.52[a]
K.Z oil®	52.63±3.72[b]	66.84±6.73[b]	80.61±4.63[a]	60.22±6.52[c]	65.08±11.71[b]
F value	3.639	10.879	4.012	4.563	5.589
L.S.D.	9.80745	9.4891	8.7974	8.77065	7.0599

The reduction percentages followed by the same letter(s) in the column are not significantly different (P< 0.05).

Table (5): Reduction percentages of the olive scale, P. olea induced by application of four insecticides on mango trees during the 2nd season, 2020

Insecticides	Weeks post treatment				General mean
	1 week	2 weeks	3 weeks	4 weeks	
Nimbecidine®	53.87±6.4[b]	74.79±5.64[a]	69.2±4.42[bc]	53.54±3.73[c]	62.85±10.7[c]
Mospilan®	60.47±6.7[b]	79.69±4.17[a]	71.51±8.12[b]	68.2±8.86[b]	69.97±9.67[b]
Admiral®	69.86±7.8[a]	76.54±7.94[a]	86.23±4.38[a]	77.66±3.24[a]	77.57±8.25[a]
K.Z oil®	71.85±6.22[a]	63.32±5.29[b]	62.89±8.18[c]	49.83±7.89[c]	61.97±10.32[c]
F value	7.587	7.263	11.372	20.318	11.033
L.S.D.	9.1305	7.93945	8.78165	8.61305	6.1597

The reduction percentages followed by the same letter(s) in the column are not significantly different (P< 0.05).

REFERENCES

Abdel-Fattah U.I., A. El-Minshaway, and E. Darwish. 1978. The seasonal abundance of two scale insects, *Lepidosaphes beckii* (New.) and *Aonediella aurantii* (Mark.) infesting citrus trees in Egypt. Pro. 4th Conf. pest. Control, NRC. Cairo (1).

Abo-Shanab A.S.H. 2012. Suppression of white mango scale, *Aulacaspis tubercularis* (Hemiptera: Diaspididae) on mango trees in El-Beheira Governorate. Egypt. Acad. J. Biol. Sci. 5: 43–50. https://doi.org/10.21608/eajbsa.2012.13870

Amer M.E.S., M.A. Salem, M.E.H. Hanafy, and N. Ahmed. 2017. Ecological studies on *Aulacaspis tubercularis* (*Hemiptera: Diaspididae*) and its associated natural enemies on mango trees at Qaliobiya Governorate, Egypt. Egypt. Acad. J. Biolog. Sci., 10(7):81-89. DOI: 10.21608/eajb.2017.12095

Attia M.I.A., H.M. El-Sharkawy, H.A. Nabil and F.S. El-Santeel. 2020. Seasonal abundance, number of generations and horizontal distribution of *Aulacaspis tubercularis* (Newstead) and its associated parasitoides on mango trees. J. Product. & Dev., 25 (3): 343-362. DOI: 10.21608/jpd.2020.132173

Ayalew G., A. Fekadu and B. Sisay. 2015. Appearance and chemical control of white mango scale (*Aulacaspis tubercularis*) in Central Rift Valley. Sci. Technol. Arts Res. J., 4 (2): 59–63. https://doi.org/10.4314/star.v4i2.8

Bakry M.M.S. and Eman F.M. Tolba. 2019. Factors affecting distribution pattern of the white mango scale insect, *Aulacaspis tubercularis* (Newstead) (Hemiptera: Diaspididae) on mango trees at Esna district, Luxor Governorate, Egypt. Assiut J. Agric. Sci., 50 (4): 87-101. Doi: 10.21608/ajas.2020.73601

Bakry M.M.S., I.R.M. El-Zoghby and Lamiaa H. Y. Mohamed. 2019. Distribution patterns of *Parlatoria oleae* (Colvee) (Hemiptera: Diaspididae) infesting mango trees. j. plant prot. & pathol., Mansoura Univ., 10 (9):437- 441. DOI: 10.21608/jppp.2019.59761

Bakry M.M.S., Lamiaa H.Y. Mohamed and Shimaa Y.E. Shakal. 2020. Climate change impact on the population size of *Parlatoria oleae* (Colvee) (Hemiptera: Diaspididae) using RCP scenarios. Int. j. res. stud. agric. sci., 7 (3): 132–149.

Baker R.F.A., S.F. Mousa, Laila S. Hamouda, Rawda M. Badawy and Sahar A. Atteia. 2012. Scale insects infesting guava trees and control measure of *Pulvinaria psidii* (Hemiptera: Coccidae) by using the alternative insecticides. Egypt. Acad. J. Biolog. Sci., 5(3): 89 - 106.

Darwish A.A.E. 2015. Susceptibility of certain fruit trees to infestation with the white peach scale, *Pseudaulacaspis pentagona* (Targioni -Tozzetti), with some ecological aspects. Egypt. Acad. J. Biolog. Sci., 8 (2): 49-58. DOI: 10.21608/eajbsa.2015.12900

Darwish A.A.E. 2020. Performance of *Aphytis lepidosaphes* Compere as a Biological Control Agent of *Lepidosaphes beckii* (New.). Journal of Entomology, 17: 27-35. https://scialert.net/abstract/?doi=je.2020.27.35

Dewer Y., S. Abdel-Razak, and A. Barakat. 2012. Comparative efficacy of some insecticides against purple scale insect, *Lepidosaphes beckii* (Hemiptera: Coccoidea) and its parasitoid in citrus orchard in Egypt. Egypt. Acad. J. Biolog. Sci., 5 (3): 121-127

El–Metwally M., S.F.M. Moussa, and N.M. Ghanim. 2011. Studies on the population fluctuations and distribution of the white mango scale insect, *Aulacaspis tubercularis* Newstead within the canopy of the mango trees in eastern of Delta region at the north of Egypt. Egypt. Acad. J. Biol. Sci., 4: 123–130. https://doi.org/10.21608/eajbsa.2011.15177

Food and Agriculture Organization of the United Nation. 2020. FAO Statistics. 1 Apr. 2020. http://www.fao.org/faostat/en/#data/QC

García Morales M., B.D. Denno, D.R. Miller, G.L. Miller, Y. Ben-Dov, N.B. Hardy. 2016. ScaleNet: A literature-based model of scale insect biology and systematics. Database. doi: 10.1093/database/bav118. http://scalenet.info.

Hamdy N.M. 2016. Some ecological aspects on mango white scale, *Aulacaspis tubercularis* and associated natural enemies infesting mango trees in Qalyubiya Governorate. J. Plant Prot. Pathol. Mansoura Univ. 7 (6): 377–383. https://doi.org/10.21608/jppp.2016.50595

Hassan N.A., S.G. Radwan, and O.M.N. El-Sahn. 2012. Common scale insects (Hemiptera:Coccoidea) in Egypt. Egypt. Acad. J. Biolog. Sci., 5(3): 153-160. DOI: 10.21608/eajbsa.2012.14275

Hassan, N.A. and S.G. Radwan. 2008. Population dynamics of *Icerya seychellarum* (Homoptera: Margaroididae) and *Rodalia cardinalis* (Coleoptera : Coccinellidae) on persimmon (Diospyros kaki) at Qalubiya Governorate. Egypt. J. Agric. Res., 86(3):1015-1027.

Kawiz, Fayza A. 2009. Ecological studies on the mango scale insect, *Aulacaspis tubercularis* Newstead (Homptera: Diaspididae) infesting mango trees under field conditions at Qualubia governorate. Egypt. J. Agric. Res., 87(1):71-83.

Lo Verde G., G. Cerasa, B. Altamore, and V. Farina. 2020. First record of *Icerya seychellarum* and confirmed occurrence of *Aulacaspis tubercularis* (Hemiptera: Coccomorpha) in Italy. Phytoparasitica, 48, 175–182. https://doi.org/10.1007/s12600-020-00792-w.

Mohamed A.A. 2002. Integrated control of scale insects on certain fruit trees. Ph. D. Thesis, Fac. of Agric., Al-Azhar University, pp. 173.

Mohamed S.E. 2002. Environmental safe approaches for controlling some scale insects infesting olive trees in new reclaimed areas. M.Sc., Thesis, Institute of Environmental Studies and Research, Ain-Shams University, pp. 84.

Morsi, G.A., M.F. Girgis and M.A. Abdel-Aziz. 2002. The Population density of the Mango scale, *Aulacaspis tubercularis* (Newstead) (Homoptera:Diaspididae) and its Parasitoids in Middle Egypt. 2nd International Conference, Plant Protection Research Institute, Cairo, Egypt: 21-24.

Moursi K.S., M.A. Boulbida, R.S. Abdel Fattah and A.K. Mourad. 2013. Some ecological aspects on olive parlatoria scale, *Parlatoria oleae* (Colvee) infested plum and olive trees under irrigation system at Burg El-Arab area, Alexandria, Egypt. Commun Agric Appl Biol Sci., 78(2):199-207. https://pubmed.ncbi.nlm.nih.gov/25145241/

Nabil H.A., A.A. Shahein, K.A.A. Hammad and A.S. Hassan. 2012. Ecological studies of *Aulacaspis tubercularis* (Diaspididae: Hemiptera) and its natural enemies infesting mango trees in Sharkia governorate, Egypt. Egypt. Acad. J. Biol. Sci., 5(3): 9-17 pp.

Ouvrard D.; T. Kondo and P.J. Gullan. 2013. Scale Insects: Major Pests and Management. *In* Encyclopedia of Pest Management. Taylor and Francis: New York, Published online: 01 Mar, 1-4. http://dx.doi.org/10.1081/E-EPM-120046899

Pino M. del, C. Bienvenido, J.R. Boyero, J.M. Vela. 2020. Biology, ecology and integrated pest management of the white mango scale, *Aulacaspis tubercularis* Newstead, a new pest in southern Spain - a review. J. Crop Prot. 133, 105160. https://doi.org/10.1016/j.cropro.2020.105160

Reda, F.A.B, M.B. Rawda, F. M.Saber, S.H. Laila and A.A. Sahar. 2009. Ecological and taxonomic studies on the scale insects that infest mango trees at Qalyubyia Governorate. Egypt. Acad. J. biolog. Sci.; 2 (2): 69- 89.

Sanad M.E. 2017. Improving an integrated programme for management scale insects and mealybugs on mango trees in Egypt. Ph.D. Diss., Fac. Agric., Ain Shams Univ, 227pp. http://research.asu.edu.eg/handle/12345678/9481

Sathe T.V., P.M. Bhoje, and A.S. Desai. 2014. Harmful scale insects (Coccidae: Hemiptera) of mango and their control. Glob. J. Res. Anal., volume: 3, (6), pp: 1-12.

Waite, G.K. 2002. Pests and pollinators of mango. In: Pe~na, J.E., Sharp, J.L., Wysoki, M. (Eds.), Tropical Fruit Pests and Pollinators: Biology, Economic Importance, Natural Enemies and Control. CABI Publishing., Oxon, UK, pp. 103–129. https://doi.org/10.1079/9780851994345.0103

.

الملخص العربي

التغيرات العددية والمكافحة الكيميائية لإثنين من الحشرات القشرية المسلحة التي تصيب أشجار المانجو

عدنان عبدالفتاح السيد درويش

قسم وقاية النبات– كلية الزراعة – جامعة دمنهور– جمهورية مصر العربية

الحشرات القشرية مجموعة خطيرة من الحشرات الثاقبة الماصة التي تتغذي علي المحاصيل البستانية وتسبب لها اضرار اقتصادية كبيرة، لذلك تم اجراء التجربة البحثية الحالية بمنطقة النوبارية، محافظة البحيرة، جمهورية مصر العربية لدراسة التغيرات العددية لإثنين من الحشرات القشرية المسلحة وهما حشرة المانجو القشرية البيضاء *Aulacaspis tubercularis* وحشرة بارلاتوريا الزيتون *Parlatoria oleae* علي أشجار المانجو وذلك خلال عامي 2019 و 2020م . حيث أوضحت النتائج المتحصل عليها أن التعداد الكلي لحشرة المانجو البيضاء سجل ثلاث قمم في منتصف يناير و 12 مارس ثم 17 سبتمبر وذلك خلال العام الاول 2019. في العام التالي 2020 كانت هذه القمم في 21 يناير و 31 مارس و 22 سبتمبر. كذلك اظهرت النتائج المتحصل عليها ان أوراق المانجو في الجزء الاوسط من الشجرة وفي الاتجاه الشرقي كانت الاكثر تفضيلا للحشرة. كذلك اظهرت النتائج المتحصل عليها ان تعداد حشرة بارلاتوريا الزيتون قد سجل ثلاث قمم في 26 مارس و21 مايو و8 اكتوبر وذلك في العام الاول. بالنسبة للعام التالي كانت قمم تعداد الحشرة في 17 مارس و 19 يونيو و29 سبتمبر. أوراق المانجو في الجزء الاسفل من الشجرة وخاصة في قلب الشجرة كانت أكثر الأوراق تفضيلا بالنسبة للحشرة. كلا الحشرتين كان تعدادهما أعلي معنويا في سطح الورقة العلوي عن السطح السفلي لها. بالنسبة لتجربة مكافحة الحشرتين فإن النتائج تشير الي أن المبيد الحشري Acetamiprid كان الأكثر فعالية ضد حشرة المانجو القشرية البيضاء ومادة البيريبروكسفين Pyriproxyfen الاكثر فعالية لحشرة بارلاتوريا الزيتون. اوضحت النتائج أيضا أن حشرة بارلاتوريا الزيتون كانت أكثر مقاومة للمبيدات المستعملة عن حشرة المانجو القشرية البيضاء.